THESIS

A RESEARCH ON STEM EDUCATION THEORY AND PRACTICES METHOD IN JAPAN AND INDONESIA USING MULTIPLE INTELLIGENCES APPROACH

多重知能アプローチを用いた、日本とインドネシアでの STEM 教育の理論と実践に関する研究

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ABSTRACT

This research was driven by the demands of the 21st century that stimulate educational reform. In Japan, according to a survey commissioned by MEXT, an additional 0.16 million researchers and 1.09 million engineers will be required by 2030 in order to preserve an annual economic growth rate of 2 percent (MEXT 2008). Due to declining fertility rates and rapid aging of the population, they are wondering whether or not this demand could be fulfilled in the future. MEXT introduced new special programs for improving literacy (MEXT 2010). One of the programs is improving STEM education development, many of the programs implemented by the Japanese government to improve STEM education in schools. However, they lack evidences of STEM education implementation in public schools or informal classes. On the other hand, Indonesia will need 113 million skilled workers by the year of 2030. Thus we need to strengthen the quality and the relevance of education because it is critical to economic and social development (Ministry of Culture and Education, 2013). The government published new curriculum, so-called the "2013 National Curriculum". The government has not implemented this reform in all regions; it has been carried out in specific areas and responses are being collected from educational practitioners. Teachers criticize this curriculum because of the thematic content, which requires them to think holistically in order to teach lessons. In other words, teachers need to integrate all subjects into a class to achieve the core competencies in students. In fact, the answer to what is the best methodology to achieve the purpose of the curriculum has not been studied yet. Therefore STEM education implementation assumed could help fulfill the demands of both countries.

Implementations of STEM education was conducted at informal settings through STEM camp activities in Japan, and at formal setting through a teacher training and class activities in Indonesia. The diversity of students' intelligences was considered in these studies. The goals were to increase STEM knowledge and interests, creativity skill, and self-development without ignoring students' multiple intelligences (MI). Data of study consist of students' MI profile, students' knowledge, students' creativity skills, and students' response (interest, agreement,

perception) of STEM education. First, multiple intelligences (MI) profile were collected using “MI Quiz” that developed by Walter McKenzie (1999) and “How Many Intelligences Are You Dominant” that adapted from Laura Candler (2011). Second, students’ knowledge data were collected from mind map of *tsunami*, concept map of natural hazard disaster, and science final examination. Third, creativity skills data were collected from solution designs and “Torrance Test of Creative Thinking” results. Finally, the responses were collected using “STEM Implementation Questionnaire” that adapted from Berlin & White (2010). Samples of these studies consisted 152 Japanese students and 632 Indonesian students.

The impacts of the implementation described in the results analysis that showed increases of STEM knowledge after camp activities in Japan (34.75 in average), and after class activities in Indonesia that higher than the traditional classes (experiment class = 77.93 in average, control class = 74.33). Most (90.8%) of the students put more interests in STEM learning, and changed their perspectives of STEM contents after camp activities significantly (pre = 2.58, post= 2.88), however they were most interested in science (3.63) than other disciplines. Moreover, Indonesian and Japanese teachers changed their perception toward science, engineering, mathematics, STEM career, and STEM integration after the training program significantly ($W_{ov} > W_{cv}$), except toward technology. The additional influence resulted in improvement of creativity skills and multiple intelligences profile in some implementation activities. In addition, there were some facts of Japanese students’ multiple intelligences profile that showed the modest and humility of estimating themselves compare to Indonesian students. This finding coherent to A. Furnham (2008) that showed Japanese student estimations of their own MI were lower than other countries.

However, based on the evaluation rubric, the implementations met some challenges such as: 1) in integrating technology (T) and engineering (E) into science (S) and mathematics (M) activities that arrived from the lack of STEM area recourses and professionals; and 2) in using STEM contexts because lack of coherency school curriculum to STEM education program characteristic that arrived from unsupported local school policy. Therefore, STEM area resources

and professionals should be improved through a periodic professional development of STEM education, and the collaboration among STEM area professionals should be involved in order to enrich the resources and to share the perceptions. This suggestion is coherent to Stohlmann, et al (2012) who thought, "*there is a need for further research and discussion on the knowledge, experiences, and background that teachers need to effectively teach integrated STEM education*". Moreover, agreements with schools samples to apply STEM education based curriculum should be achieved in order to improve using of STEM contexts.

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New Education Issues in Japan

Science education in Japan has a history of 70 years after the World War II, and during this time science curriculum has been a lot of changes and revising with variation purposes depending on the development of scientific knowledge. The contexts of science education in Japan are fulfilling these basic characteristics of the newest course study: Challenging to highly knowledge creation system in science and technology, education for the sustainable society, formative or authentic assessment, and focusing on more inquiry based learning (MEXT, 2008).

At the era of modern science and technology into contents of society, Kumano (2013) wrote that Japan has issues of some uncertainties that scientist can't answer. Therefore, science and technology governance is rising up as a new issue. They start accepting argumentations that are subjective will from each stakeholder into policy formation that was developing with the communication and discussion among government careers, scientist, business workers, local communities, and nations in Japan. Huge tsunami disaster on 11th March 2011 also triggers for this consideration to reexamine the framework of science education. The disasters has been given many lessons for the Japanese how to deal with the unpredicted natural hazard, stimulate them to increase knowledge in science and technology related to daily life in a society development. Somehow, the question of how to fulfill better qualities of citizenship required by science and technology governance has no answered yet. However, it is needed to engage students in scientific inquiry and engineering practice.

Ishikawa & Fuji (2012) analyzed some facts of international competitiveness of Japan's science and technology. Japan has not only achieved successes in targeted areas of science and technology, but also has managed substantial scientific output through research activities that carried out in its universities and research institutes. However, according to a survey commissioned by MEXT, on top of the maximally projected increase in researchers, an additional 0.16 million

researchers and 1.09 million engineers will be required by 2030 in order to preserve an annual economic growth rate of 2 percent (MEXT 2006:91-104) and due to declining fertility rates and rapid aging of the population, they are still wondering whether or not this demand could be fulfill in the future.

Furthermore, they also mentioned the 'PISA Shock' in 2006, where Japanese student's achievement was decreased. Japan performance in international comparison of primary and secondary education in PISA and TIMSS; invoke a sense of impending crisis threatening the Japanese education system (see table 1.2). They concluded that poor performances in literacy on PISA and reasoning on TIMSS were attributed to weaknesses of Japanese STEM education and strongly influenced STEM education policy thereafter (Kudo 2012:2). It was revised by generating new guideline with by considering STEM capacity and quality of instruction. Thus, MEXT introduced new special programs of "Basic Plan for the Promotion of Education" for improving literacy (MEXT, 2008) and national surveys targeting primary and junior secondary education were conducted in the latter half of the 2000s (Matsushita 2010:3-5). One of the programs was improved STEM education development; many of the programs implemented by the Japanese government to improve STEM education in schools and promoted a broad base of general scientific understanding and interests in society are administered through the Japanese Science and Technology Agency (JST), such as establishing Training Centre for Core Science Teacher. This aim was to combat "rika banare", or apathetic attitudes toward science among Japanese youth, by increasing the number of qualified STEM teachers who are confident and enthusiastically committed to teaching science subjects. MEXT also allocated a maximum of 35 million JPY per year for four years to be awarded to ten selected universities cooperating with local governments, for a total of 340 million JPY per year. Upon its inception in 2009, seven programs were selected and financed through the initiative. The following year five additional programs were selected, and in 2011 two more were added. Again in 2012, two universities were selected and provided with 20 million JPY each.

However, in the public eye, realignment of policy spanning this period has definitively shown that academic strength is achieved through increased contact hours and study content. Providing students with flexibility and 'room' of growth may have its merits, but the relaxed education measures fell short of achieving their goal of enhancing students' enthusiasm or interests

Table 1.1: Japan PISA Result

PISA	Mathematic Literacy	Scientific Literacy	Reading Literacy	Number of countries
2000	1 (557)	2 (550)	8 (522)	32
2003	6 (534)	4 (548)	14 (498)	41
2006	10 (523)	6 (531)	15 (498)	57
2009	9 (529)	5 (539)	8 (520)	65

from; PISA Database, http://www.oecd.org/pisa/pisaproducts/

Table 1.2: Japan TIMSS Result

Mathmatics	4th grade	8th grade
1995	3/26 (567)	3/41 (581)
2003	3/25 (565)	5/46 (570)
2007	4/36 (568)	5/48 (570)
2011	5/52 (585)	4/45 (570)

from TIMSS, http://timssandpirls.bc.edu/timss2011/index.html

Many families and schools failed to take advantage of the flexibility afforded through relaxed education policy to promote creative and independent learning of children. Instead, children and young students filled spare hours playing computer games and exchanging phone text messages (Oki 2011:136-142). On the other hand, there lacks evidences of STEM education implementation in public schools or classes. The implementation of high-level STEM education are able seen in SSH (Super Science High) school programs that developed and carried out special advanced curricula of mathematics or science, including collaborative study programs with universities or research institutions focusing on teaching logically and creative thinking through observations and experiments. Lectures and presentations in English are also held in order to strengthen international communication ability.

<u>New Education Issues in Indonesia</u>

Education in Indonesia regulated by government based on constitution on 1945 that has the goal to educate all nation. Indonesia government has changed the curriculum periodically since 1947. It was done to repair the educational system and also to improve educational quality in Indonesia. Curriculum completions have been doing continuously as an effort to adjust them with science

and technology development and also society demands. It was done to get the perfect proportion of learning goals, student potentials, neighborhoods conditions and facilities. Therefore, science education has a great role in enhancing them, especially to increase qualified students who are creative, critical, logic and initiative toward the issues in society which occurs as a result of science and technology development (Kumano & Suwarma, 2012).

Recently, government published new curriculum, called “2013 National Curriculum”. This was a completion from the previous curriculum because of unsatisfied competences, of graduates, the heavy broad and irrelevant contents, teacher centered and textbook oriented learning, and cognitive focused assessments. This is also triggered by the new challenges faced in the rich technology and information era that impact on modernization, globalization, science and technology development. Mckinsey Global Institute (2012) stated an unleashing Indonesia’s potential that it is having 55 million skilled workers in the Indonesian economy today, it is predicted that Indonesia will need 113 million skilled workers in 2030, thus we need to improve quality and relevancy in education because it is critical to economic and social development (Ministry of Culture and Education, 2013).

A child who has received a good education tends to be a better parent, make informed decisions, earns a better living, adopts new technology, copes with crises, and be a responsible citizen (World Bank, 2011). Thus, education is an important aspect that should be considered by a government to develop the nation by having qualified human resources. Qualified human resources are developed by qualified educational system that includes teachers, policy maker and students. Indonesia is one of developing countries, which still needs qualified human resources to build it. In addition, 53% populations in cities are producing 74% of GDP, and then we have to prepare social engineering in order to achieve 71% population in cities that will produce 86% of GDP.

One of the big challenges that should be faced by Indonesian student in this century is to compete in TIMSS and PISA. Indonesia delegated eighth grade students to join TIMSS in 2011, the result showed that there is a decrease average score of science and mathematics compare to 2007 TIMSS results (see appendix A.1.1). It is also noted that Indonesia had the national target population that did not include international target population (Martin, 2012). Furthermore, PISA result (see appendix A. 1.2) of Indonesian students also was not exciting. This

Program of International Students Assessment assesses the extent to which 15-year-old students have acquired key knowledge and skills that are essential for full participation in modern societies. The assessment, which focuses on reading, mathematics, science and problem-solving, does not just ascertain whether students can reproduce what they have learned; it also examines how well they can extrapolate from what they have learned and apply that knowledge in unfamiliar settings, both in and outside of school. In the latest year, Indonesian students rank was in second position before the bottom rank (OECD, 2012). This showed that they have low-key knowledge and skill that essential for full participation in modern scientist. The students were not ready enough to compete in international competition and join in modern science.

New released curriculum is one strategy that developed by government to enhance educational quality in order to create qualified students to compete in international world. The completion of curriculum framework between 2013 curriculum and the previous ones is illustrated in table below.

The development of the curricular framework in Indonesia refers to the Constitution and follows several phases. In 2004, the first phases of curriculum development began with design of the framework followed by structure and content standards (development of thematic contents for grades I and II) that delivered standards for processes, graduate competencies, and assessment. The second phase after developing these three sets of standards, the government developed guidelines, syllabi and sample lesson plans. The third phase was textbook development, learning and assessment, which were conducted by the educational units (local governance). In 2006, in the third phase the government established a new policy that the development of syllabi, lesson plans, textbook development, learning and assessment, would be conducted by educational units (local governance) and developed thematic content for grades I- III. This curriculum was called Kurikulum Tingkat Satuan Pendidikan (KTSP). In 2013, the government changed the framework of the curriculum development process. In the first phase, they analyzed student profiles and the needs in relation to national educational goals, and then the second phase, improved graduate competency standards from which were derived processes, framework and assessment standards. Content standards were developed from the curriculum structure that followed the curricular framework. At the third phase, the development of syllabi, lesson plan, textbook development, learning and

assessment was took place by the government. Thematic content is designed for grades I- VI. The completion of curricular framework between the previous curricula and the 2013 curriculum is illustrated in detail in Table 1.3, which describes differences in graduate competency standard, content standards, courses of study, and phases of development processes.

Table 1.3: Curriculum Framework Completions

No.	KBK 2004	KTSP 2006	2013 Curriculum
1	Graduate competency standards derived from content standards		Graduate competency standards derived from needs
2	Content standards formulated based on course purposes, as specified in the standards for graduate competencies and basic competencies of the course of study		Content standards derived from graduate competency standards through free core competencies of the course
3	Course of study that develop attitudes, skills and knowledge was separated		Every subject have to contribute to developing attitudes, skills, and knowledge
4	Competencies derived from course of study		Course of study derived from competence
5	Courses of study independent of each other, such as separate groups of lessons		Every course of study banded by core competencies (each classes)
6	The development of the curriculum until up to the syllabi	The development of curriculum until up to the basic competence	The development of the curriculum until up to the text book and teachers' guidelines book
7	Thematic content for grades I and II (refer to course of study)	Thematic content for grades I–III (refer to course of study)	Thematic content for grades I–VI (refer to competencies)

Source: Ministry of Education and Culture 2012

The main purpose of this new curriculum is to create productive, innovative, creative, and good effective human resources, through reinforcement of attitude, skill and knowledge in order to face challenges in the 21st century. The government has not implemented this reform in all regions; it has been carried out in specific areas and responses are being collected from educational practitioners. Teachers criticize this curriculum because of the thematic content, which forces them to think holistically in order to teach lessons. In other words, teachers need to integrate all subjects into a class to achieve the core competencies in students. In fact, the answer to what is the best methodology to achieve the purpose of the curriculum has not been studied yet. However, the integration of science and technology plays an important role in creating the citizenry needed in this century

(Furner & Kumar, 2007).

Skills Needed in 21st Century

The 21st century is the era of high science and technology development as symbols of modernization that stimulating the globalization. Regardless much opinions of 21st Century's definition, there is agreements that we need to develop demanded human resource with required literacies to survive in this era. ISTE views crucial technology literacy that needs highly skilled labors with higher-order thinking skills and skills for digital citizenship to be effective lifelong learners and productive members of a globalized society. ISTE standards include broad categories such as, the ability to 1) demonstrate creativity and innovation, 2) communicate and collaborate, 3) conduct research and use information, 4) think critically, 5) solve problems and make decisions, and 6) use technology effectively and productively.

Furthermore, Bybee (2013) proposed STEM literacy that different from science, technology, engineering and mathematics literacies. This affects from US science education development that starts considering STEM (Science Technology Engineering and Mathematics) education as a crucial way to cope with the challenges and demands of this century. This literacy came from idea that as literate adults, individuals should be competent to 1) understand STEM-related global issues; 2) recognize scientific from other non scientific explanations; 3) make reasonable arguments based on evidences; and very importantly, 4) fulfill their civic duties at the local, national, and global levels. Some of skills should be included in STEM program is 1) non-routine problem solving skill that need their metacognition to linked the knowledge conceptually with a broad spam of information and 2) their creativity skills to generate new and innovation solution integrate seemingly unrelated information, and entertain possibilities others may miss (Houston 2007, Bybee, 2013).

Based on those literacies, creativity is one of the skills that needed in facing this century demands and challenges. Interventions targeted at improving creative thinking have also been successful in increasing student academic achievement (Maker, 2005). Furthermore, Lubart and Giuignard (2004) argue more generally that as technology continues to advance, people will increasingly be required to think in creative and divergent ways in order to address new types of problems. In turn, creativity itself precipitates additional societal and technological changes in that it drives the development of new ideas, inventions, and technologies.

On the other hand, facing the force of globalization in this century, Gardner, H (2007) proposed five minds that should be cultivate in the future to build skills, such as discipline mind, synthesizing mind, creating mind, respectful mind and ethical mind. In the mantle of educator, he invites people to develop these five kinds of mind by considering the differences among individuals fade into the background because he believes that human was born with multiple intelligences. His notion of intelligence is the existence one or more basic / core information-processing operation or mechanisms, which can deal with specific kind of input. Lazear, D. (2004) referred this core operation as intelligence capacities as key to strengthening all intelligences. Gardner viewed intelligence as 'the capacity to solve problems or to design product that is valued in one or more cultural setting' (Gardner & Hatch, 1989:4). He argued that human has at least seven intelligences areas; verbal linguistic, logical mathematical, visual spatial, musical rhythmic, bodily kinesthetic, interpersonal and intrapersonal intelligences. In solving problems, all intelligence is needed to work together, the greater the number of outlets one can find in the expression, the more likely is one to find creative approaches to problem situations (Gardner, 1999). However, individuals have one or two superior intelligences profile (Suwarma & Kumano, 2013) that becomes their characteristics in solving problems and attains knowledge that can influence their learning style.

PURPOSE OF THE STUDY

Being referred on two different education systems in Indonesia and Japan, it noted the needs for innovation in science education. For instance, the need of changing of curriculum process in Indonesia, are seeking an answer of method to reach curriculum graduate competence standards. On the other hand, science and technology governance start to be considered by Japan in order to survive from geographic and global challenges. The main purpose of this study is to analyze different STEM implementation strategy in the contexts of both countries by considering multiple intelligences of each student and analyzing the creativity skill, and challenges of its implementation.

Nowadays, STEM is a sputnik moment that urges the education reform in US. Even though the implementations were not given a significant impact to the development country yet, the fame was spread out all over the nation and become

a systemic educational reform. Regardless of the different perspective that occurred, could this implementation fulfill the demands and face the challenges? It needs decades to know the answer, and researches would help find the answer.

STEM has been called meta-discipline, creation of disciplines based on integration of other disciplines into a new “whole”. STEM education offer students a holistic experiences and knowledge of the world by integrating the disciplines into cohesive teaching and learning paradigm. In education, Bybee (2013) is not viewed STEM as an abbreviation of disciplines, but it has purposes. Generally, it triggers students to be literate in STEM. STEM education teaches all students learn to apply basic contents and practices of the STEM disciplines to the situations they encounter in life In other words; STEM literacy is literacy refers to an individual’s:

a. *knowledge, attitudes, and skills to identify questions and problems in life situations, explain the natural and designed world, and draw evidence-based conclusions about STEM related-issues;*
b. *understanding of the characteristic features of STEM disciplines as forms of human knowledge, inquiry, and design;*
c. *awareness of how STEM disciplines shape our material, intellectual, and cultural environments; and*
d. *willingness to engage in STEM-related issues and with the ideas of science,technology, engineering, and mathematics as a constructive, concerned, and a re!ective citizen.*

(Bybee, 2013, p. 5)

Since STEM education is new issues in Japan and Indonesia, there are lacks of scholar that tries to implement them at schools. Thus, researches of those implementation in public school both in middle and elementary school are needed. The strategies are different depend on context of each country. In 2013, Kumano lab conducts research of STEM implementation in the context of Japanese education. We design summer STEM camp in order to identify the process of implementation that focusing on engineering activity. We introduce engineering Define-Develop solution-Optimize iterative cycle design that promotes in NGSS (2013), and identifies what kind of solution developed by the student to solve tsunami issues after giving them engineering activities. In 2014, we get fund from JST program and we design programs for scientists in the next generation to implement STEM education, one of its activities is summer STEM in July and

September 2014. The purposes of these activities are the same, but more focused on assessing 21st century skills.

In the contexts of Indonesia, we bring STEM education into elementary and middle school to be applied in the classrooms. This viewed not only as active response to international challenges and competition, but also as an answer of method and strategy to reach education goals in new released curriculum. This study will focus upon the challenges of implementation by considering student's multiple intelligences and creativity skill. The results are compared with different implementation strategy in Japan. In conclusion, the purposes and rationale of this research are shown in figure 1.1.

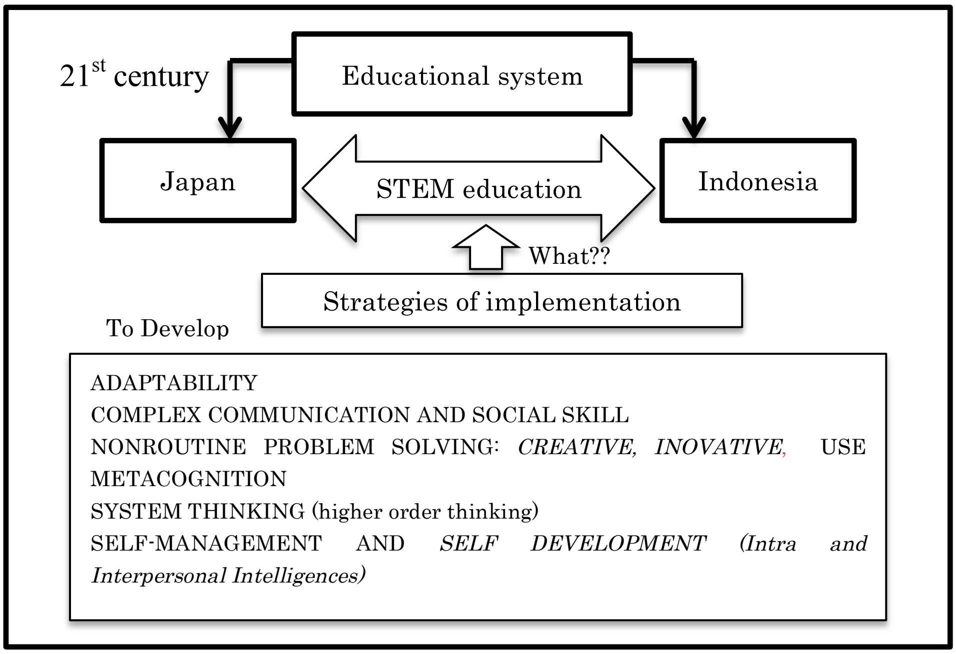


Figure 1.1: Research Rational Diagram

SIGNIFICANCE OF THE STUDY

STEM education implementation already conducted in almost all states in the US. They are the parts of sputnik moment that US wants to become a world leader in innovation by improving 21st century skills of Science, Technology, Engineering and Mathematics through educational reform.

However, these implementations do rarely in Indonesia and Japan, although both countries already consider the challenges in 21st century. By using the same framework and literacy of STEM in U.S, an experiment of STEM education implementation was conducted and analyzed in different strategies and context.

The researches were analyzed the challenges, multiple intelligences and creativity skill profile in both countries.

RESEARCH QUESTION

Based on the science education purposes of this study, the research questions are characterized into two categories:

1. <u>How was different students' multiple intelligences profile in Indonesia to student's profile in Japan?</u>

1.1 How was different undergraduate student's multiple intelligences profile in Indonesia to student's profile in Japan?

1.2 How was different middle school student's multiple intelligences profile in Indonesia to student's profile in Japan?

1.3 How was different the students' multiple intelligences (MI) profile before and after learning process in one semester?

2. <u>How was different STEM implementation in Japan from Indonesia?</u>

2.1. How STEM education implementation in Japan STEM summer camp 2013 was?

2.1.1. How was different students' knowledge of *tsunami* before and after STEM camp?

2.1.2. How was students' creativity in solving *tsunami* problem?

2.1.3.Did students show MI characteristic based on their strength/dominant intelligences profile?

2.1.4. What did occur challenges in this first implementation?

2.2. How was STEM education implementation in Japan STEM summer camp in 2014?

2.2.1. How was different students' knowledge of natural disaster and STEM before and after STEM camp?

2.2.2. Were students show MI characteristic coherent to their strength / dominate intelligences?

2.2.3. How were students' creativity skill profile differed before and after STEM camp activities?

2.2.4. How was student creativity skill in solving *natural disaster* problem?

2.2.5. How was students' response to STEM education implementation?

2.2.6. What were the challenges arouse in this second implementation?

2.3. How was STEM education implementation in Indonesia school in 2013 - 2014?

2.3.1. How was teachers perception of STEM integration based on KTSP and 2013 curriculum?

2.3.2. How was teachers' self-reflective on STEM education implementation?

2.3.3. How was STEM education application in classroom?

a. How was student response to the implementation?

b. How were students creative thinking skill in solving problem?

c. How the implementation result was differ without and with considering multiple intelligences?

2.3.4. What were the challenges arouse in this implementation?

DEFINITION OF TERM

Intelligence: *bio-psychological potential to process information that can be activated in a cultural setting to solve problems or create products that are valued in at least one culture* (Gardner, 1989). Intelligence examines as composites of fine-grained neurological sub-processes but not sub processes themselves, as bio-psychological information processing capacities, and as the bases on which an

individual can participate in meaningful activities in the boarder cultural miles (Gardner, 2006, p.227)

Multiple intelligences: Gardner suggested that every human possesses at least eight independent abilities or intelligences. They are shown in table below:

Table 1.4: Multiple Intelligences Area

Area of Multiple Intelligences	
Verbal-linguistic intelligence (V-L)	*The ability to use a native or foreign language, to communicate by reading, speaking, writing and listening, express opinions and to understand other people*
Logical-mathematical intelligence (L-M)	*The ability to reason effectively, to explore principles and cause-effect relationships, to classify, to understand complex relationships, to from hypotheses and questions*
Visual-spatial Intelligence (V-S)	*The ability to recover blanks in the mind, to imagine the shape and appearance of three dimensional objects*
Musical-rhythmic intelligence (M-R)	*The ability to like music, to melodize, to remember melodies, to recognize sounds*
Body-kinesthetic intelligence (B-K)	*The ability to use all of the body such as hands, feet and fingers for the aim of solving a problem, doing something, or presenting a product*
Social- interpersonal intelligence (S-I)	*The ability to understand other people, to realize their personality traits and interactions, to establish positive relationship with them, a vital human intelligence displayed by good teachers, a famous example is Gandhi*
Intrapersonal intelligence (I-I)	*The ability to find one self, to realize who one is, one's weaknesses and strengths, one's feelings*
Naturalist intelligence (N-I)	*The ability to understand, know the natural environment and to realize differences in nature*

STEM: abbreviation of Science Technology Engineering Mathematics that defines based basic disciplines.

- *Science: deals and seek the understanding of the natural world* (NRC 1996, p.24), is the underpinning of the technology.

- *Technology: as defined in ITEEA's Standard for Technological Literacy, is the modification of natural world to meet human wants and needs* (ITEA/ITEEA, 2000/2002/2007 p.7). Technology help us to improve our health; to grow and proceed food and fiber better; to harness and use energy

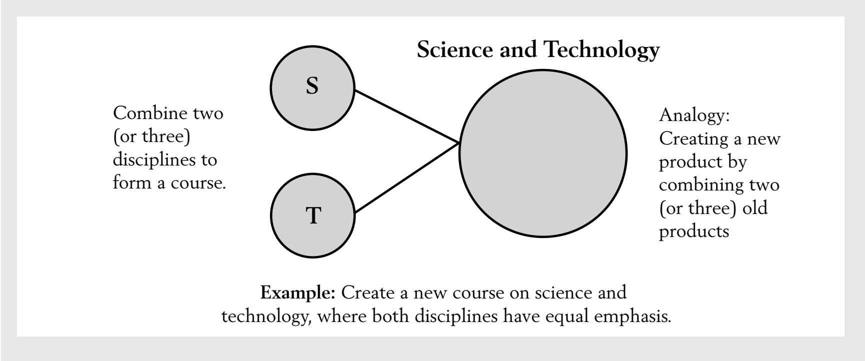
more efficient; to communicate more effectively; to process data faster and accurately; to move people and things easier; to make product to enhance our lives; and to build structure that provide shelter and comfort (Dugger, 2011).

- Engineering: *an activity that seeks to meet identified needs of people and societies by the purposeful application of engineering sciences, technology and techniques to achieve predicted solutions that use available resources efficiently, are economical, that manage risks; engineering is carried out by practitioners performing roles differentiated by the level of problem analysis and solution, the activity to be managed, risk and responsibility*. (International Engineering Alliance (IEA), 2011,p.1)

- Mathematics: *is the science of pattern and relationship* (The American Association for the Advancement of Science (AAAS), 1993, p.28). It provides an exact language for science, technology and engineering.

STEM education: STEM is viewed not only as disciplines but also have purposes in education. *STEM education for all students is to learn to apply basic content and practices of the STEM disciplines to situations they encounter in life*. (Bybee, 2013, p.5)

The implementation of STEM education in Indonesia is defined as integrating two or three STEM discipline in class. The first step of implementation was conducted teacher training that followed by several teacher in the school sample, where teachers were asked to perceive whether or not STEM could be integrated into the curriculum, and then create a lesson plan that would be implemented into the class. The class implementation was observed and student response was taken to analyze the impact of implementation to students. The perspective of this implementation is illustrated in the figure below:



(Source: Bybee, 2013, p.78)

Figure 1.2: STEM definition scheme in Indonesia

STEM in Japan implementation is defined as trans-disciplinary program that applies in STEM Summer Camp program. In 2013, this program brings issues of tsunami, ask students to design a solution of tsunami problem that might be occurring again in the future. In 2014, this program brings issues of natural disaster that might be occurring at student neighborhoods in the future. Students were asked to design a sustainable environment in society. These activities might be an example in which the entire group of STEM disciplines, and perhaps others (e.g., ethics, politics, economics), would be used to understand a major contemporary challenge. This perspective could be seen in Figure 1.3.

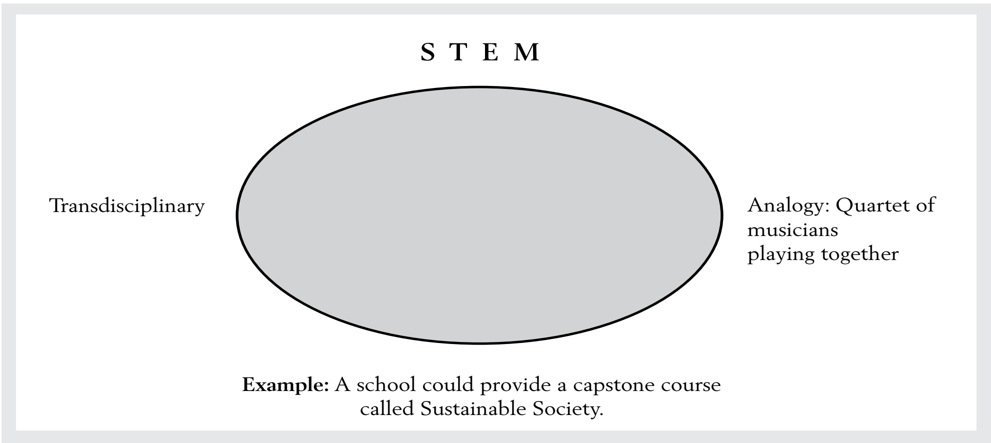


Figure 1.3: STEM definition scheme in Japan

Source: Bybee (2013, p.79)

Creativity: *is a personal way of using and directing your own abilities* (Brandt 1986: Penick.J, 1995, p.84). *Creativity is the generation of new ideas either by new ways of looking at existing problems or seeing new opportunities. Design is something links creativity and innovation. It shapes ideas to become practical, attractive propositions for people* (Bell. P, 2010, p.1). *Well-posed question stimulates thinking, revealing alternate point of view and logic, and may be viewed as embodiment curiosity. Question to stimulate creativity must require multiple possible answer and demand action.* (Penick. J. 1995, p. 84)

Challenge: an objection or resistance that face in the implementation processes. Bybee wrote that there are some challenges in implementing STEM education in US, such as:

- *Integrating engineering and technology in classroom*: Scaling up technology and engineering courses and appropriately including the *T* and *E* in science and mathematics education seem to be reasonable ways to meet this challenge. He note that this approach maintains a "silo" orientation for the separate disciplines that is, all four disciplines are represented separately (Bybee, 2013)
- *Using context of STEM*: Addressing this challenge requires an educational approach that first places life situations and global issues in a central position and uses the four disciplines of STEM to understand and address the problem. "It has been referred to as *context-based science education* (Fensham, 2009) and could easily be represented as a context based STEM education.

Problems: In context of Japan, the problem posed to student is *tsunami* and natural hazard disaster, while in context of Indonesia are design balloon powered car and living things classification.

Multiple Intelligences instrument: self-estimate assessment that collects MI profile of samples, which is chosen and translated based on student school level. For undergraduate students, the instrument is multiple intelligence survey developed by Walter McKenzie in 1999. For junior high school students, the instrument is How Many Ways Are You Dominant, which is adapted from Laura Candler (Teaching Resources at http://home.att.net/~teaching).

CHAPTER II
LITELATURE RIVIEW

INTRODUCTION

Technology transformed human life in one-way to another for a thousand years. For instance, the mechanism of agriculture that changed from using hands and simple tools to sophisticated machine. These machines help farmers to increase their production and rise up their income. In other fields, technology creates easier communication internationally. This impacts on fast and easy information's transfers around the world and trigger the globalization. Jerald (2009) noted that new technologies combine with demographic, political and economic changes have altered human's work and social lives in ways of significant consequences for today's young people.

Those facts have prompted educators argue that the traditional curriculum is not enough. Schools must provide the students with "something new" as a preparation to face the 21st century. Indonesia and Japan are realizing this need. Thus they are moving to the new policy. In Indonesia, it is developed a new curriculum that more emphasized on creating productive, innovative, creative, good affective human, through reinforcement of attitude, skill and knowledge in order to face challenges in the 21st century. On the other hand, Japan decides to put more attention on emphasizing science and technology education through enhancing science and technology promotion in education to students by providing some grants for researchers and practitioners (Ishikawa, Fuji & Moehle, 2012). However, this brings a question for the researchers of what methods and strategies are needed to fulfill new policies goals. In order to answer that question, aim of this research is **analyzing different method and strategies on fulfilling new policy goals by implementing STEM education in the contexts of Japan and Indonesia with considering individual potencies**.

Different frameworks of 21st Century and its skills, new issues of STEM education in education reform, NGSS as reference to get the skills in lesson, challenges of STEM education implementation, and individual diversity in multiple intelligences and creativity, were analyzed in order to support this research.

21^{ST} CENTURY SKILL

About 1.5 decades have been facing the 21st century; most researchers defined it as the rich technology and information era that trigger globalization and modernization. What kinds of skills are needed to face this century? Educators answer it from the view of “21st Century Learning”. They thought what kind of learning environment should be developed in this century. Mishra＆Kereluik, K (2011) wrote that there were feelings that there was a distinct disjuncture between the centuries that force us to emerge into, and the educational demands of this new century have required new ways of thinking, teaching and learning. Recently there have been many of books and governmental reports that have been criticizing the current goals and practices of schooling (Keengwe, Onchwari & Wachira, 2008; Kozma, 2003; Zhao, 2009). These authors and groups of researchers suggest that schooling needs to be fundamentally reconsidered to emphasize higher order cognitive processes such as critical thinking, creative problem solving, curiosity, and adaptability. In parallel, there are individuals and groups who offer a range of suggestions for what are broadly labeled “21st Century Skills.” These recommendations emerge from educators such as Howard Gardner and organizations such the Partnership for 21st Century Learning, and OECD.

Punya Mishra et al. (2011) analyze 10 governmental report and books that defined 21^{st} century skill. I picked seven of them based on the type of organization and individual interest. They were compared and summarized. They were summarized in figure 2.1. From the figure 2.1, it concluded that most of organization or researchers view 21^{st} century as an age of technology, science, globalization, digital world, modernization and interconnected world. Skills that needed derived from their frameworks and standards. Considering “what” and “what student need”, Mishra (2011) categorized the need by foundational knowledge, meta-knowledge and humanistic knowledge.

<u>Foundational knowledge</u> in my opinion, it relates to work of brain in mastering or understanding knowledge. On the other hand, Mishra (2011) categorized it into *core content knowledge, information literacy and cross-disciplinary knowledge*.

From the figure 2.1*, core content knowledge* often stated in their standards and high academic achievement in traditional domain as essential skills that needed by students for success in 21^{st} Century.

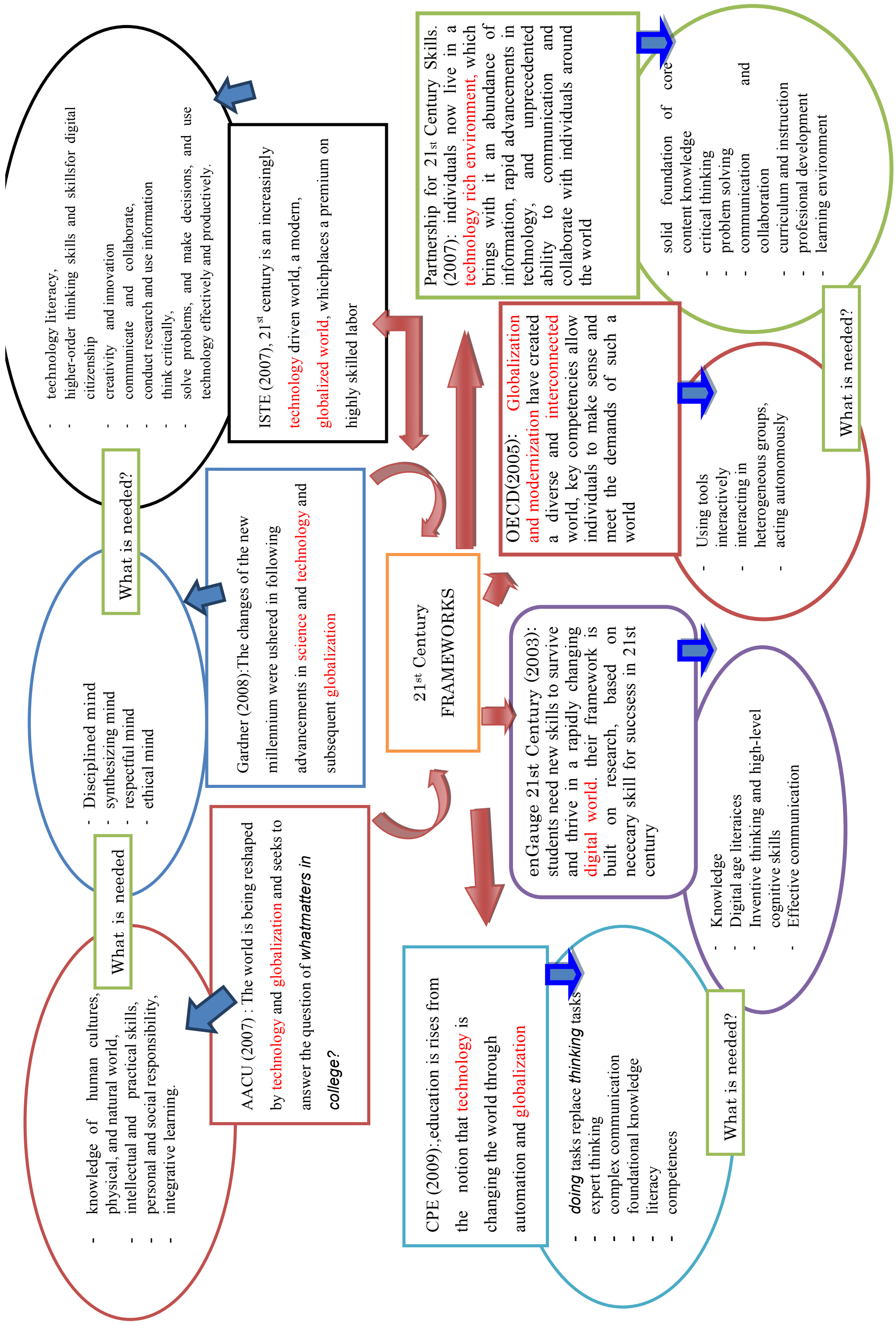


Figure 2.1: 21st Century Frameworks and Skills Diagram

American Association for College and Universities (AACU) mention knowledge of human cultures, physical, and natural world; Gardner propose discipline mind; Center for Public Education (CPE) talked the need of advance knowledge in traditional subject; and Partnership 21st Century (P21) focus on core subject and literacies such as financial and business, environmental, health and civic literacy.

Furthermore, *information literacy* viewed by some organizations such as International Society for Technology in Education (ISTE), P21, Organization for Economic Cooperation and Development (OECD), and AACU as necessary skills. Mishra (2011) argued that information literacy most often involves the skills necessary to seek out effectively, organize and process information from a variety of media. Information literacy was deliberately chosen to include all types of media, while media is increasingly becoming digital, print media is still quite prevalent and such of understanding is necessary for academic and economic success. Information literacy also includes a component of responsible use of technology and media; also it is an important moral and ethical consideration beyond understanding basic ICT systems and media forms.

The last category is *cross-disciplinary knowledge* that related to abilities to synthesize. AACU and Gardner asserts it to be crucial to success in the 21st century as it also involves the ability to understand, organize and connect the vast amounts of information now available with the advent of digital media.

<u>Meta-knowledge</u> related to the process how to work with foundational knowledge. Mishra (2011) categorized it into *problem solving/ critical thinking, communication/collaboration and creativity/ innovation*.

Mishra (2011) viewed that the ability of problem solving and critical thinking most often needed in cognitive skills that is necessary for success in economic and social domains. Furthermore, he wrote that critical thinking frequently involves the ability to interpret information and make informed decisions based on such information. These terms discussed by CPE, ISTE, AACU, enGauge, and P21.
Communication and collaboration skills are cited as essential in 21st Century concerning to group diversity in globalized and sharing information. This

skill emphasized by OECD, P21, ISTE, enGauge, and AACU, while Gardner mentions this skill implicitly in his respectful and ethical minds.

Creativity and innovation also viewed as crucial skills needed in this century because of the highly complex problems facing society in the 21st Century necessitate new and creative solutions. Creativity and innovation included the ability to evaluate the effectiveness of ideas and products; also they elaborate on existing products of ideas, and refine ideas and products in pursuit of specific end goals. This terms cited by ISTE, AACU, Gardner, enGauge, and P21.

Humanistic knowledge, in the contexts of broader and global society, it relates to learners' self-vision. It is categorized into life/job skills, cultural competences and ethical/emotional awareness. Life/ job skills point out the lifelong learning that should be considered; cultural competences refer to culture diversities from globalization; and ethical/ emotional awareness defined as ability to imagine oneself to someone else's position and feel with that individual emotion. This ability also comes from fact of diversities.

Another organization, NRC (2010) viewed five important skills in 21st Century. There are adaptability, complex communication skills, non-routine problem solving skills, self-engagement and self-development, and system thinking. These skills were adapted as essential skills that developed in conducted STEM program by Bybee (2013).

Further question for these skills are "where and how can we get and sharpen these skills?" Educators will answer these questions with confidence that education reform is proper field to get and sharpen it, but how it processes cannot be answered easily by concerning demographical, economical, cultural, and political changes.

STEM EDUCATION SEEMS TO BE AN ANSWER IN THE UNITED STATES

The US government realizes the lack of scientists and engineers because of the interest decrease in science, mathematics, engineering and technology field that impact on the interest decrease in these careers. To solve these problems, government emphasizes STEM improvement in education.

Hays Blaine (2009) wrote that science, technology, engineering and mathematics (STEM) education often has been called a meta-discipline, the "*creation of a discipline based on the integration of other disciplinary knowledge into a new 'whole*'. This interdisciplinary bridging among discrete disciplines is now treated as an entity, known as STEM (Morrison, 2006). " STEM education offers students one of the best opportunities to make sense of the world holistically, rather than in bits and pieces. STEM education removes the traditional barriers erected between the four disciplines, by integrating them into one cohesive teaching and learning paradigm. Morrison and others have referred to STEM as being an interdisciplinary approach. "*STEM education is an interdisciplinary approach to learn where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy* (Tsupros, 2009)."

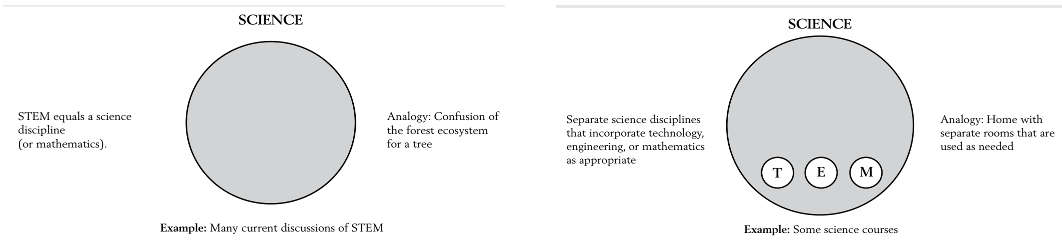
In addition, Bybee (2013) resumes the definition of STEM education that already conducted by several educators. He wrote that STEM perspectives come in many ways not only as interdisciplinary approach but also as other perspectives (see Figure 2.2). He does not indicate which one is the true STEM perspective, he rather help individuals, organizations, and agencies clarifying different perspectives and providing insights to those consideration or engaging in education reform with a particular STEM perspective. He emphasizes to create STEM literate society; a deep technical workforce for a 21st-century economy, and an advanced researches and developments focused on innovation.

He defines STEM literacy refers to an individual's

1. *knowledge, attitudes, and skills to identify questions and problems in life situations, explain the natural and designed world, and draw evidenced-based conclusions about those STEM-related issues;*

2. *understanding of the characteristic features of STEM disciplines as forms of human knowledge, inquiry, and design;*

3. *awareness of how STEM disciplines shape our material, intellectual, and cultural environments; and*



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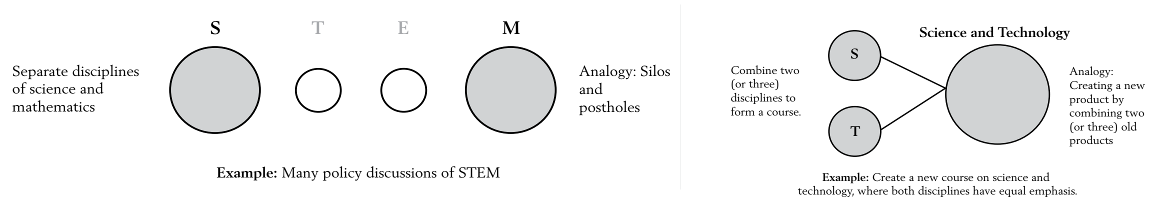

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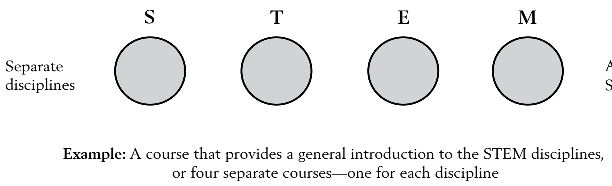

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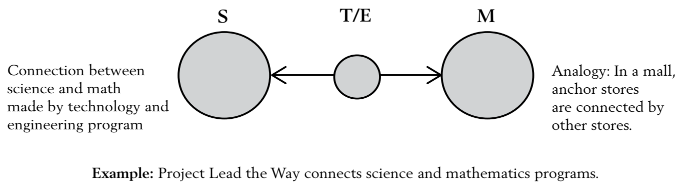

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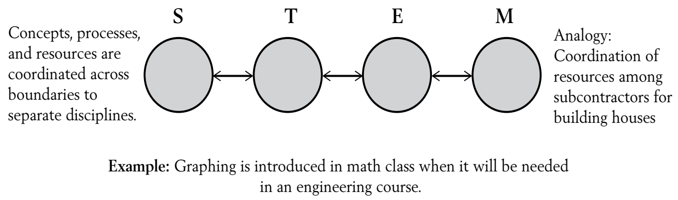

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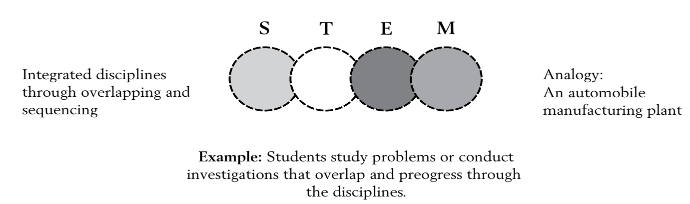

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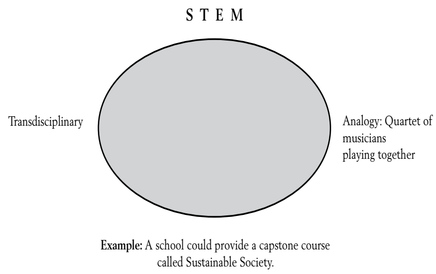


(i)

(a) STEM equals science or mathematics.
(b) STEM means Science and incorporate technology, engineering or mathematics.
(c) STEM means both science and math
(d) STEM equals a quartet of separate discipline
(e) STEM means science and math connected by technology and engineering.
(f) STEM means coordination across disciplines
(g) STEM means complementary overlapping across disciplines
(h) STEM means combining two or three disciplines
(i) STEM as trans disciplinary program or course

Figure 2.2: STEM Education Perspectives

4. *willingness to engage in STEM-related issues and with the ideas of science, technology, engineering, and mathematics as a constructive, concerned, and reflective citizen.*

(Bybee, 2013, p.5)

He adapts the NRC (2010) 21st Century skills to be included in STEM program. The program can introduce complex communication skill through laboratories or investigation activities by including group works. It should help the students develop a non-routine problem solving skill by requiring the learner to apply knowledge to scientific questions and design technological problems. Students identify the mathematical component and contemporary issues, and use reasoning to link evidences to explanations. He adds that curriculum material should provide the student to work on STEM investigation by themselves and in-group so that students can develop self-management and self-development abilities. At last, he writes that one of the most helpful innovations in STEM education is emphasized on system thinking. Think systematically how the entire system works and how an action, change, or malfunction in one part of system affects the rest of all system.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Further question arises after a STEM education issue is what standards should be embedded in the implementation. The National Research Council (NRC) decided to publish new standard, Next Generation Science Standards (NGSS) that started by developing new K-12 framework of science standard which rich in contents and practices, arranged in a coherent manner across disciplines and grades to provide all students an internationally bench marked science education. There are three dimensions of the framework: scientific and engineering practices, crosscutting concepts, disciplinary core ideas (physical science, life science, earth and space sciences, engineering, technology, science and society). The framework is designed to help realize a vision for education in the science and engineering in which students actively engage in scientific and engineering practices and apply crosscutting concepts to deeper their understanding of the core ideas in this field.

The implementation of STEM education in this study is based on engineering design in the framework of NGSS. The term "engineering design" has replaced the older term "technological design," consistent with the definition of

engineering as a systematic practice for solving problems, and technology as the result of that practice. According to the framework, "From a teaching and learning point of view, it is the iterative cycle of design that offers the greatest potential for applying science knowledge in the classroom and engaging in engineering practices" (NRC 2012, pp. 201-2). The Framework recommends that students explicitly learn how to engage in engineering design practices to solve problems. The core idea of engineering design includes three component ideas:

a. *Defining and delimiting engineering problems* *involves stating the problem to be solved as clearly as possible in terms of criteria for success, and constraints or limits.*

b. Designing solutions to engineering problems *begins with generating a number of different possible solutions, and then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.*

c. Optimizing the design solution *involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.*

(NGSS, Appendix I, p.2)

From a global perspective, engineering offers opportunities for "innovation" and "creativity" at the K-12 level. Engineering is a field that is critical to undertake the world's challenges, and exposure to engineering activities (e.g., robotics and invention competitions) can spark interests in the study of STEM or future careers (National Science Foundation, 2010). This early engagement is particularly important for students who have traditionally not considered science as a possible career choice, including females and students from multiple languages and cultures in this global community.

INDIVIDUAL IS DIFFERENT: MULTIPLE INTELLIGENCES IN EDUCATION

Individual differences created dilemmas in education (Randi. J, 2005). Some educator thought that the student differences should be minimizing by giving them "uniform treatment". This appears on the surface to be fair since no favoritism had apparently been shown. In contrast, Gardner felt that this was unfair by considering the privilege of one profile intelligence. He didn't agree to

this condition where the students were valued in the same single intelligence by minimizing other intelligences. On the other hand, he (Gardner, 2003) really pleased with scholars whom already integrated the MI theory into learning processes that showed a positive result even though there are some different views of it. Some scholar views MI theory as a rationale of art education, some thought it as the pretext of a new track, and others suggest it as a way of teaching in a different way based on the various intelligence.

Gardner theory argued in psychological fields because of the lack experimental evidence (Waterhouse, 2006), but it was accepted openly in the education field. Moran (2006) responded this argument. She wrote that Gardner worked many researches for this theory. For instance, Gardner works to understand and formulates how the subcomponents comprise an intelligences and developmental studies such as identification of core systems of numerical, linguistic and causal reasoning (1994; Gardner, Brownell, Wapner, & Michelson, 1983). Furthermore, he (Gardner, 1993) noted, "*While multiple intelligences theory is consistent with much empirical evidence, it has not been subjected to strong experimental test…Within the area of education, the application of the theory are currently being examine in many projects. Our hunches will have to be revised much time in light of actual classroom experience*". After twenty years of study, he analyzed that MI should not in and of itself be an educational goal, but if one's educational goals encompass disciplinary understanding, then it is possible to mobilize several intelligences to help achieve that goals (Gardner, 2003). The implementation of MI theory in curricula and learning processes will help the teacher to reach education goals.

Gardner (1999) said that in the heyday of the psychometric and behaviorist era, it was generally believed that intelligence was a single entity that was inherited and that humans are initially blank slates who could be trained to learn everything, if he/she provided that in an appropriate way. Gardner, (1993) viewed that nowadays, an increasing number of researchers believe precisely the opposite: that there exists a multitude of intelligences, quite independent of each other; that affords its own strengths and constraints to the individual.

Gardner viewed intelligence as '*bio-psychological potential to process information that can be activated in a cultural setting to solve problems or create products that are valued in at least one culture*' (Gardner & Hatch, 1989 p4). He argued that human had multiple intelligences (MI), and he formulated seven

intelligences, which then developed into nine. This new outlook on intelligence differs greatly from the traditional view, which usually recognizes only two intelligences, verbal and computational. The seven intelligences area are Linguistic/Verbal (V-I), Musical-Rhythmic (M-R), Logical Mathematical (L-M), Visual-Spatial (V-S), Bodily Kinesthetic (B-K), Social Interpersonal (S-I) and Intrapersonal (I-I) Intelligences. Recently he adds Naturalist Intelligences.

Concerning to 21st century demands, Gardner (2008) proposed five minds that needed in this century. He argued that the changes of the new millennium were ushered in following advancements in science and technology and subsequent globalization. According to Gardner, these changes necessitate new education processes, as the educational system was not designed to respond to the needs of the new digital and global age. Education needs to adapt to stretch and shape the minds of learners in five ways that will lead into the future. His first mind is *discipline mind* that owned by mastering one or more disciplines. It means that we need to master at least one discipline that usually attains in school or less formally through some combination of apprenticeship and self-instruction. Second is *synthesizing mind*, the mind that can survey a wide range of sources, decide what is important and worth paying attention to; and then put this information together in ways that make sense to oneself, and ultimately to other person as well. This is a necessary skill for success in the new age because of the vast amount of easily accessible information. Third is *creating mind*, a mind to generate new ideas, ask and seek answers to important unasked questions. People who have this skill to attempt new things, monitor whether their works, cast continuously for new ideas and practices, picked themselves up after an apparent failure, and so on. Fourth is *respectful mind*. The human's capacity to distinguish among individuals and among groups of individuals leads them to have a respectful mind that starts with the assumption that diversity is positive and world would be a better place if individuals sought respect to one another. Fifth is *ethical mind*, a person possessed an ethical mind is able to think of him or her abstractly, and is able to work beyond self-interest in conjunction with the needs of society at large.

Related to multiple intelligences (MI), he thought various intelligences involve in development of five minds. The *discipline* and *creating* minds can and do draw on any intelligence depending on the area of work. *Respectful* and *ethical* minds clearly draw on personal intelligences. Ethics mind which reflecting an abstract way of thinking draws as well as on logical intelligence. On the other

hand, *synthesizing mind* poses a problem for MI, because synthesize operation involves one two or even more intelligences. He suspected that the people who had synthesizing mind achieved their goals in different ways, for example: he relies heavily on linguistic, naturalistic and logical intelligences, but others might be drawn on spatial artistic and personal intelligences.

CREATIVITY AND MULTIPLE INTELLIGENCES IN STEM EDUCATION

There are some definitions of creativity. For instance, Brandt (1986) defined creativity as a personal way of using and directing your own abilities; Marianne Guldbrandsen (as cited in Bell. P: 2010) defined creativity as the generation of new ideas either by new ways of looking at existing problems or seeing new opportunities. Teresa Amabile (2005) wrote that creativity arises through the confluence of following three components:

Knowledge *defines as all the relevant understanding that an individual brings to bear on a creative effort.*

Creative Thinking *is relates to how people approach problems and depends on personality and thinking/working style.*

Motivation *is generally accepted as key to creative production, and the most important motivators are intrinsic passion and interest in the work itself.*

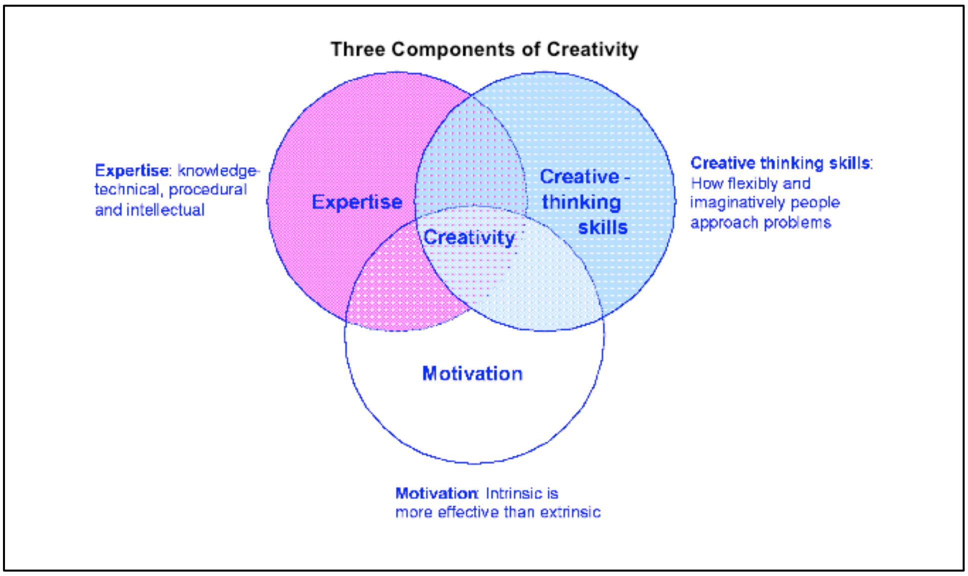


Figure 2.3: Three Component of Creativity

Furthermore, John Penick (1996) wrote that in the process, creative person may restructure the problem rather than merely seeking solution to the problem presented. Questions to stimulate creativity must require and allows multiple possible answers and demand action.

Torrence (1974), who has developed tests of creative thinking, describes creativity as being responsive to problems, insufficiencies, lack of information, unavailable elements and inconsistencies and as identifying challenges, searching for solutions, making predictions, building hypothesis regarding deficiencies or changing hypothesis, choosing one of the solution methods and trying, trying again and presenting the results afterwards. Moreover, Torrence and Goff (1989) stated that creative thinking is not a singular talent; but it contains many talents within. Taking something from its simple form and detailing, enriching and developing that something and describing it differently than others and conventional ways are characteristics of creativity.

There are several ways to assess the creativity. It depends on how do we assess the concept of creativity that we refer to. For instance, creativity is assessed through a design in the engineering field; it was reflected in UK-SPEC (2010) that characterizes chartered engineers as individuals who are able to develop design solutions to engineering problems through "creativity, innovation, and change". Incorporated Engineers are characterized by an ability to "act as exponents of today's technology through creativity and innovation." (Peter Ball, 2010). Mike Goatman (in Peter Ball, 2010) viewed that the creative ' design' sector is usually employed to produce solutions and the outcomes are considered to be the measure of success.

Torrance (1974) developed the instrument to assess the 'capacity of creativity'. That is TTCT (Torrance Tests of Creative Thinking). He developed two forms of creative thinking test; the verbal and figural. The TTCT-Verbal and the TTCT-Figural are two versions of the TTCT. The TTCT-Verbal has two parallel forms, the A and B, and consists of five activities: ask-and-guess, product improvement, unusual uses, unusual questions, and just suppose. The stimulus for each task includes a picture to which people respond in writing (Torrance, 1966, 1974). The TTCT-Figural has two parallel forms, the A and B, and consists of three activities: of picture construction, picture completion, and repeated figures of lines or circles. Trifingger (1985) wrote that Torrance did not conclude from his test can assess all dimension of creativity. He suggested not using it alone as a

basis of decision. Moreover, he stated that showing a high degree of these abilities on TTCT does not guarantee a person chance of behaving creatively; it should be supported by creative motivation and skills (Kyung Hee Kim, 2006; Torrance, 1990; Torrance & Bell, 1984). Torrance has been identified with his famous creativity tests, but actually it was not his main goals.

Torrance's main focus was on understanding and nurturing qualities that help people express their own creativity. The tests were not designed to measure creativity, but instead to serve as tools for its enhancement (Hébert, Cramond, Neumeister, Millar, & Silvian, 2002). Torrance (1966, 1974) suggested the following uses for the tests: *a) to understand the human mind and its functioning and development, b) to discover effective bases for individualizing instruction, c) to provide clues for remedial and psychotherapeutic programs, d) to evaluate the effects of educational programs, materials, curricula, and teaching procedures, and e) to be aware of latent potential*.

TTCT scoring systems had been improved in 1984 by designing the streamline scoring system. It refered to Guilford (1986) ideas that considered creative thinking as involving divergent thinking, but he did not noted the same as divergent thinking because creativity require sensitivity to the problem as well as redefinition abilities, which included transformations of thought, reinterpretations, and freedom from functional fixedness in driving unique solutions. Scoring systems refer to five subscales below:

1. *Fluency: The number of relevant ideas; shows an ability to produce a number of figural images.*
2. *Originality: The number of statistically infrequent ideas; shows an ability to produce uncommon or unique responses. The scoring procedure counts the most common responses as 0 and all other legitimate responses as 1. The originality lists have been prepared for each item on the basis of normative data, which are readily memorized by scorers.*
3. *Elaboration: The number of added ideas; demonstrates the subject's ability to develop and elaborate on ideas.*
4. *Abstractness of Titles: The degree beyond labeling; based on the idea that creativity requires an abstraction of thought. It measures the degree a title moves beyond concrete labeling of the pictures drawn.*

5. *Resistance to Premature Closure: The degree of psychological openness; based on the belief that creative behavior requires a person to consider a variety of information when processing information and to keep an "open mind."*

Table 2.1: Coherencies of 21st Century Skills and Multiple Intelligences in STEM Education

21st Century Skills (NRC, 2010)	Multiple Intelligences that needed (Gardner, 1993)
1. **Adaptability:** The ability and willingness to cope with uncertain, new, and rapidly changing conditions on the job include responding effectively to emergencies or crisis situations and learning new tasks, technologies, and procedures. Adaptability also includes handling work stress; adapting to different personalities, communication styles, and cultures; and physical adaptability to various indoor or outdoor work environments (Houston 2007; Pulakos, Arad, Donnovan, and Plamondon 2000).	**Intrapersonal intelligence:** Enables individuals to recognize and distinguish among their own feelings, to build accurate mental models of themselves, and to draw on these models to make decisions about their lives. Intrapersonal intelligence is sometimes seen in those individuals who make sound choices about their life and work. **Social interpersonal intelligence** The ability to understand other people, to realize their personality traits and interactions, to establish positive relationship with them, a vital human intelligence displayed by good teachers, a famous examples of which is Gandhi
2. Complex communications and social skills: Skills in processing and interpreting both verbal and nonverbal information from others to respond appropriately. A skilled communicator is able to select key pieces of a complex idea to express in words, sounds, and images to build shared understanding (Levy and Murnane 2004). Skilled communications negotiate positive outcomes with customers, subordinates, and superiors through social perceptiveness, persuasion, negotiation, instruction, and service orientation (Peterson et al. 1999)	**Verbal linguistic intelligence** The ability to use a native or foreign language, to communicate by reading, speaking, writing and listening, express opinions and to understand other people. It allows individuals to communicate and make sense of the world through language. Those who have a keen sensitivity to language in its spoken and/or written forms **Visual spatial intelligence** The ability to interpret graph, pictures, perceive visual or spatial information, to transform this information, and to recreate visual images from memory.

Table 2.1: continued

21st Century Skills (NRC, 2010)	Multiple Intelligences that needed (Gardner, 1993)
3. Non-routine problem solving: A skilled problem solver uses expert thinking to examine a broad span of information, recognize patterns, and narrow the information to reach a diagnosis of the problem. The ability to reflect on whether a problem-solving strategy is working and to switch to another strategy that is working if the current strategy is not (Levy and Murnane 2004). This ability includes creativity to generate new and innovation solutions, integrate seemingly unrelated information, and entertain possibilities others may miss (Houston 2007).	**Logical mathematical intelligence** The ability to reason and calculate, to think things through in a logical, systematic manner. The ability to reason effectively, to explore principles and cause-effect relationships, to classify, to understand complex relationships, to from hypotheses and questions
5. Systems thinking: Systems thinking means the ability to understand how an entire system works and how an action, change, or malfunction in one part of the system affects the rest of the system—that is, adopting a "big picture" perspective on work (Houston 2007).	**Social interpersonal intelligence** **Intrapersonal intelligence** **Logical mathematical intelligence** **Visual spatial intelligences** **Verbal linguistic intelligence** **Physical Body kinesthetic intelligence** **Naturalistic Intelligences**

Creativity is an essential skill that needs to be included in STEM education program. It was reflected from Bybee suggestion that it should be included in the STEM program as one of critical skills that included in 21st century skills framework from NRC (2010). The coherences between these skills and multiple intelligences theory are shown in Table 2.1.

Developing our creative faculty requires exploring the full potential of all our intelligence and talent, not just the ones accorded the most prestige by society. This requires a constant awareness and utilization of all aspects of our beings. We need to open to all forms of knowledge, learning and expression. When the multiple intelligences are developed, it tends to reinforce the performance of each other. The greater the number of outlets one can find in the expression, the more likely is one to find creative approaches to problem situations (Gardner, 1999).

Furthermore, Stenberg (2009) notice that the ones are not born with a fixed level of wisdom, intelligences, or creativity, but rather developed these attributes over time. All of us born with some genetic predispositions, but during the course of a lifetime, these predispositions are modified by our experience such that they are developed at a different rate and with a different level of success as a function of the interaction between genes and environment. (Stenberg & Grigorenko, 1999:2009)

Stenberg (1997,1999) defined that successful intelligences are the ability to achieve one's goal in life, given one's sociocultural contexts by capitalizing on strength and correcting or compensating for weakness, in order to adapt to shape, and select environment, through a combination of analytical, creative, and practical abilities.

Robert E. Yager in 1987 (Kumano, 1993) developed the creativity domain. He wrote that there were some specific important human abilities in creativity domain: visualizing, producing mental images, combining objects and ideas in new ways, producing alternate or unusual uses for object, solving problem and puzzles, fantasizing, pretending, dreaming, designing devices and machines and producing unusual ideas.

Some researchers investigated relationship between creativity and intelligences, for instance Gardner (1995) indicated a close relationship between creativity and the domain where certain intelligence was manifest; and for Getzels and Jackson (1962) and Torrance (1962), intelligence and creativity were independent. Ferrando, M.1, Prieto, M.D, Ferrándiz, C, and Sánchez, C. (2005) indicated low relationships between creativity and intelligence. Nonetheless, the relationship between them changes according to how the intelligence construct is conceptualized. In general, they said that there was a greater relationship between creativity and multiple intelligences. Likewise, the threshold theory (Stenberg, 1999) is not upheld when IQ is related to creativity: pupils with a greater Intelligence Quotient are not the most creative. Nonetheless, from the multidimensional perspective, the threshold theory is corrugated for visual-spatial, naturalist and linguistic intelligence.

CHAPTER III
METHODS AND PROCEDURE

SAMPLE SELECTION

For this study sample divided into two categories, STEM education implementation in Japan and in Indonesia.

<u>Japan:</u>

1. for research question 1: *How student's multiple intelligences profile in Indonesia was different to student's profile in Japan?*
    a. Question 1.1: samples are 62 undergraduate science students (12 chemistry, 11 physics, 9 biology, 11 geology, and 19 science education) in faculty of science education.
    b. Question 1.2 and 1.3: samples are 40 students of 2nd grade in *Fuzoku* Junior High School.
2. for research question 2: *How STEM implementation in Japan was different from Indonesia?*
    a. Question 2.1: samples are 29 elementary students from some schools in *Fujieda* and *Shizuoka-Shi*. Samples come from students who interest in science that join the science informal activity.
    b. Question 2.2: samples are 21 elementary and junior high students from some school *in Hamamatsu* and *Shizuoka-Shi*. All samples are purposive sample that chosen from talented student in science.

<u>Indonesia</u>

1. for research question 1: *How student's multiple intelligences profile in Indonesia was different to student's profile in Japan?*
    c. Question 1.1: samples are 492 undergraduate science students (69 chemistry, 105 physics, 99 biology, 107 mathematics, and 112 computer science) in faculty of science and mathematics education.
    d. Question 1.2: samples are 100 students of 2nd grade Cikarang-Indonesia Middle School students
2. For research question 2 : *How STEM implementation in Japan was different from Indonesia?*

This study is conducted in Muhamadiyah 8 Primary and Secondary School Bandung, which has vision to create a better student in the future to build the

country. Their mission is to be a leading Islamic school in science and technology. This vision and mission were coherence to STEM education. Thus, they are interested in and welcome to implement it. Students come from middle to high economical family; they choose the school because of their extra class of Islamic lesson. The classes start at 6.30 and end at 15.30 for third to sixth grade and secondary students. 74 teachers involve in elementary level and 22 in secondary level. Elementary has 6 classes each level, on the other side, secondary has 3 classes for 8th grade and 4 classes for 7th grade. STEM education training followed by seventeen math and science teachers (12 elementary and 5 secondary). Samples are 40 students in 1st grade that took randomly from four 1st grade classes.

DESIGN AND PROCEDURE

The research was designed experimentally, with several methods of implementation to measure the increase of student's knowledge, MI profile and creativity skills. A research design of STEM education implementation from 2012 – 2014 are described in figure 3.1. Different methods of implementation took in 2013 and 2014 because of its cultural setting and context. It was implemented at informal sector in Japan and formal sector in Indonesia.

<u>Japan</u>

In 2012, multiple intelligences profile was collected in undergraduate and middle school student level in order to analyze characteristics and profile of Japanese student in Shizuoka. Furthermore, in 2013, first implementation of STEM education was conducted through a summer camp program that emphasized on exploring student's characteristic of MI and identifying the process of implementation that focusing on engineering activity. We introduced Define-Develop solution-Optimize an iterative cycle of design that promoted in Next Generation of Science Standards (NGSS, 2013), and identified student creativity by analyzing what kind of solution design that made by the students in solving tsunami issues after we gave them engineering activities. This program was repeated in 2014 with some additional activities that more concerned to student characteristic of MI exploration activities, and natural disaster related activities.

The implementation method is shown in figure 3.2, 3.3a and 3.3b.

Indonesia

Implementation of STEM education was started in 2013. It has been implementing since November 2013 at a private junior high school in Bandung West Java Indonesia. Selected school has vision to improve student achievement in science, technology, engineering and mathematics. The principal wants students to be literate in STEM, to create better human resources to develop the country and to improve school quality and to have better achievement in science and technology.

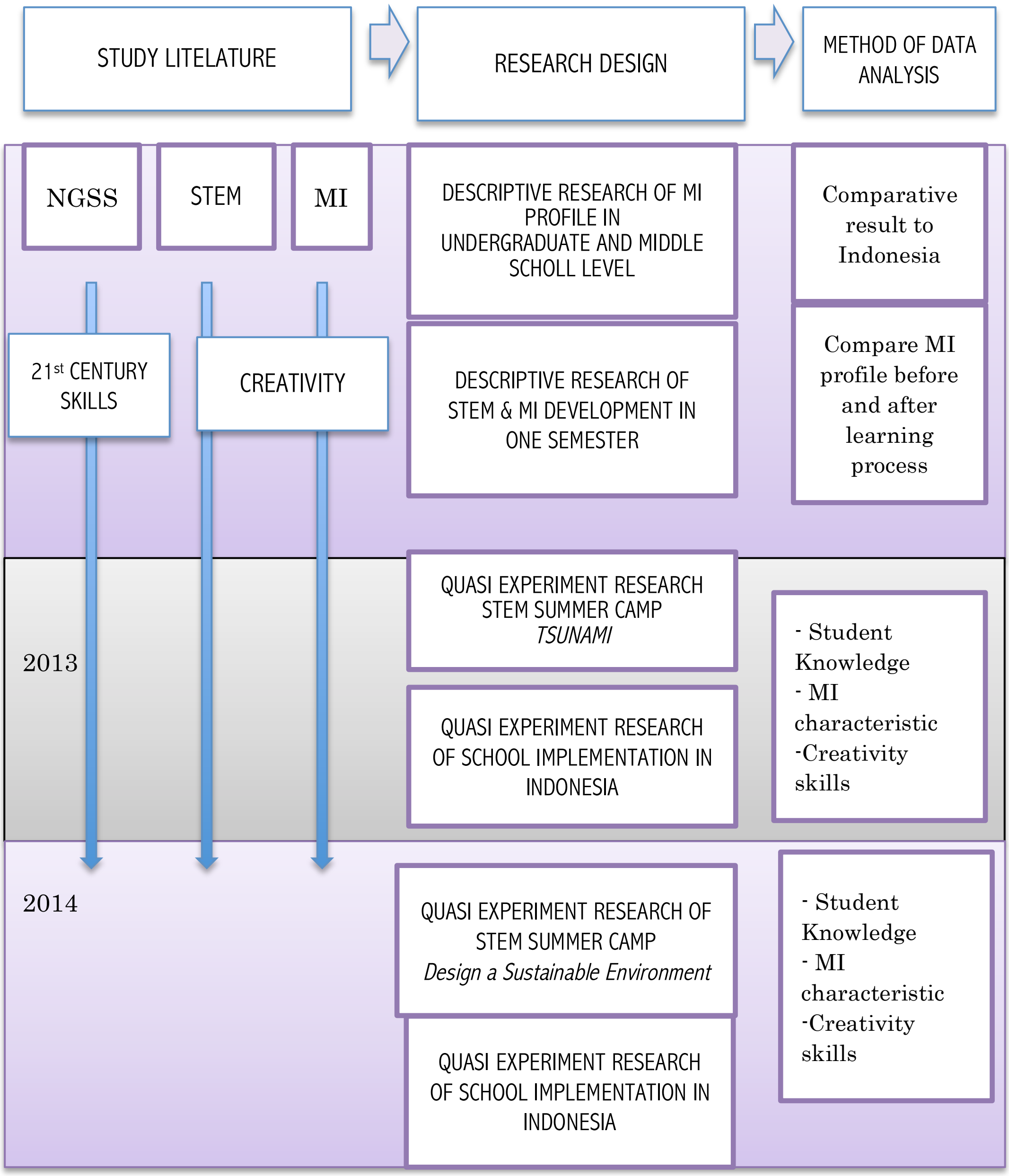


Figure 3.1: Research Flowchart

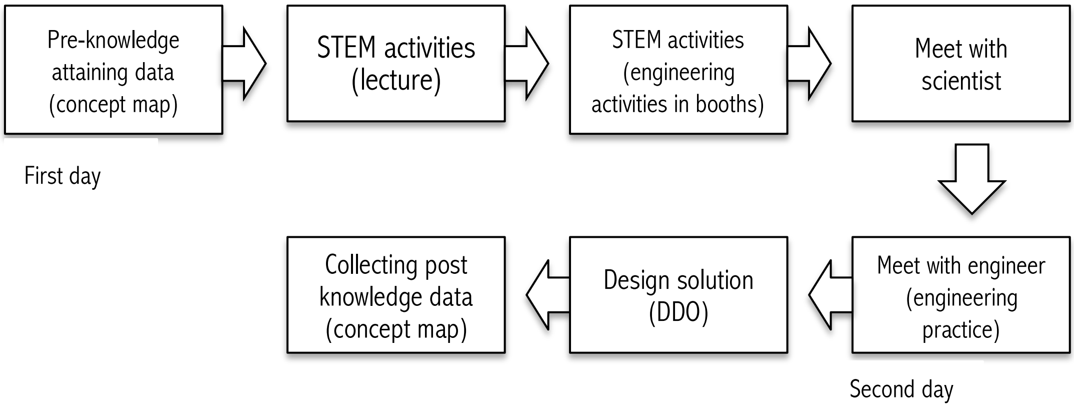


Figure 3.2: Implementation Methods in STEM Summer Camp 2013

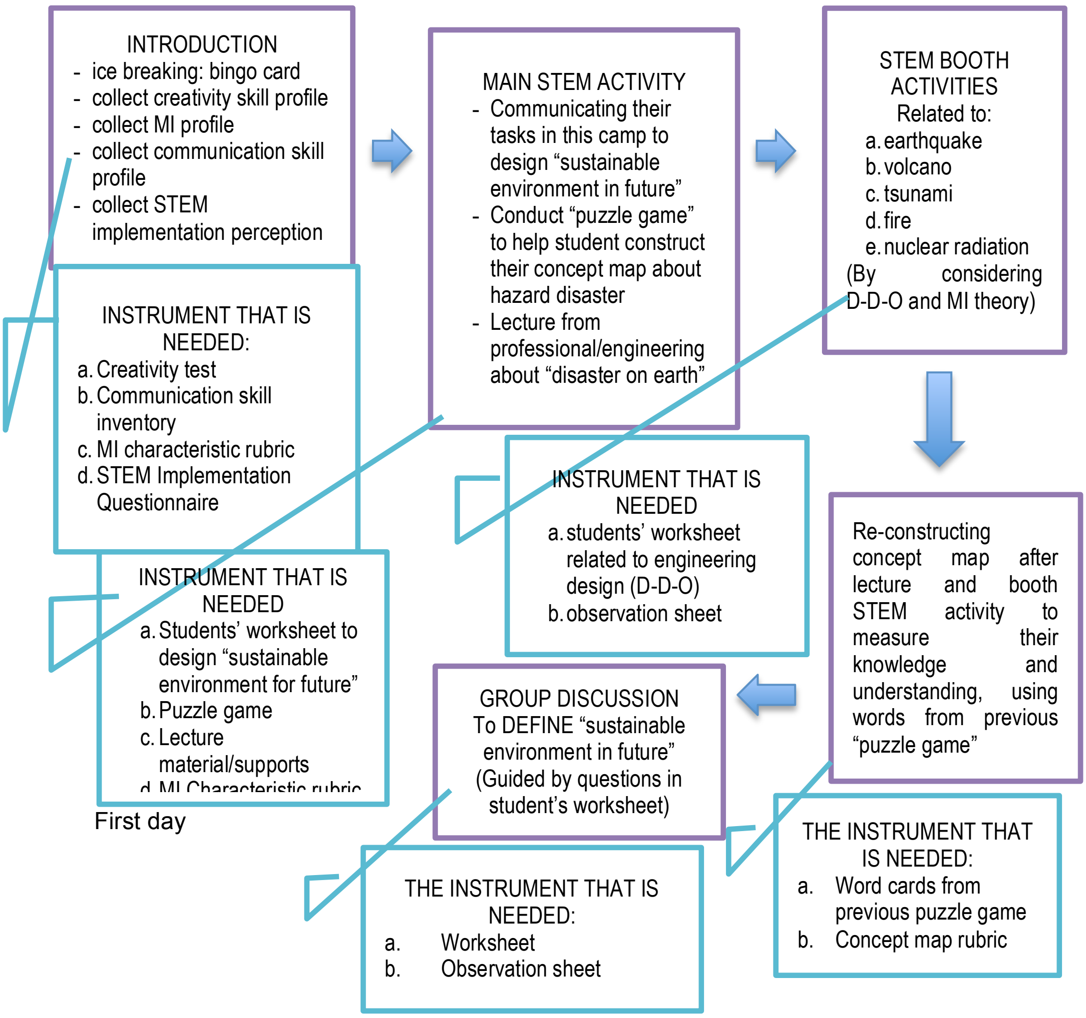


Figure 3.3a: Diagram of Implementation Method in STEM Summer Camp 2014

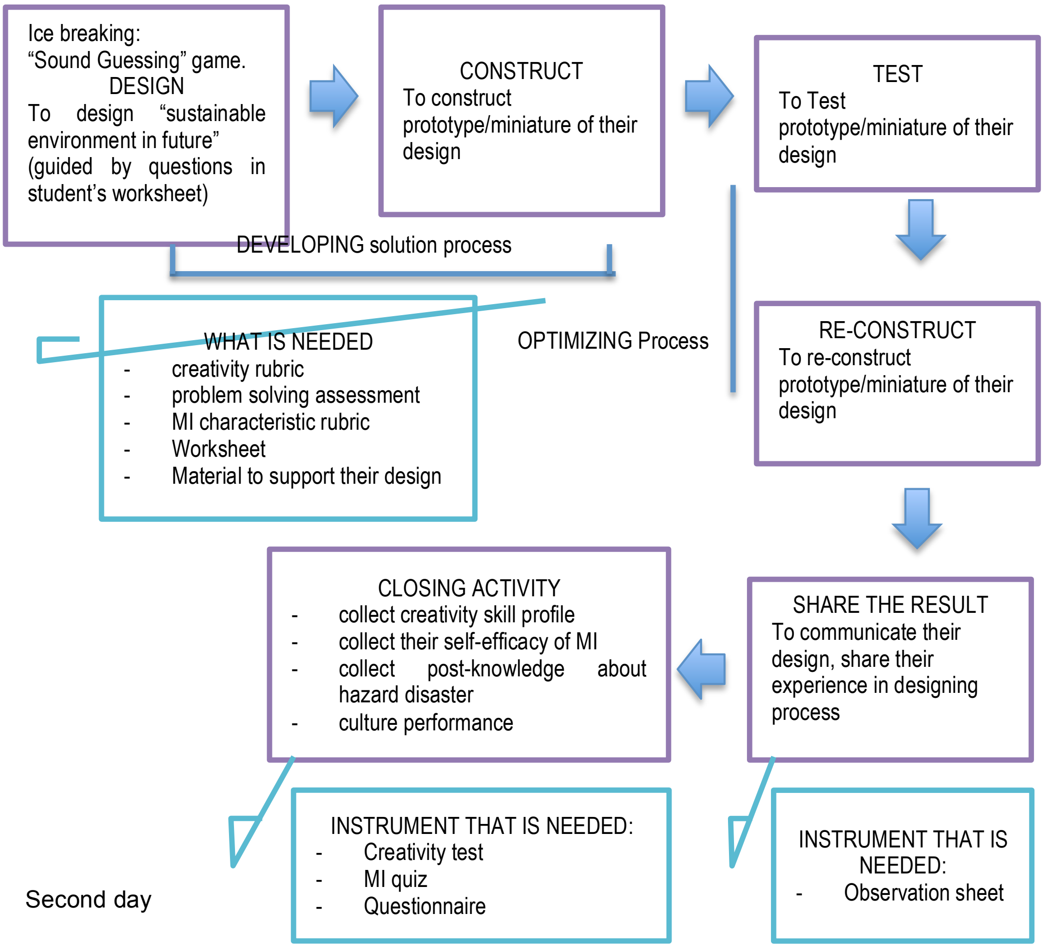


Figure 3.3b: Diagram of Implementation Method in STEM Summer Camp 2014

The implementation in Indonesia was started with teacher training and its applications in learning process. In this training, teacher were explained STEM education and National Curriculum 2013, they were asked to analyze whether or not it is appropriate to be integrated in the curriculum, they were given STEM activity, and were asked to create lesson plan to implement STEM in class. In order to analyze students learning process, the class implementation was observed by other teachers and some students were interviewed correlated to their response. The training conducted once a week from 9.00 a.m. – 16.00 p.m. They were given different STEM activity in each meeting. The figures 3.4 and 3.5 below show method and activity of the implementation.

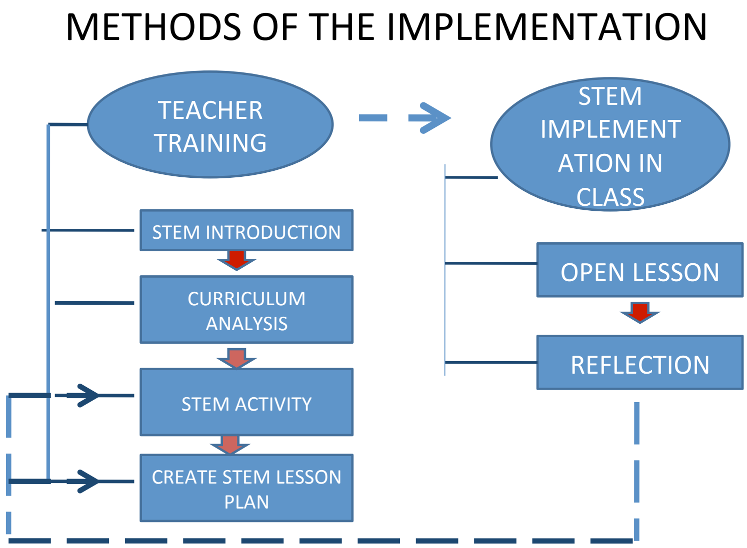


Figure 3.4: Diagram methods of STEM education implementation in Indonesia

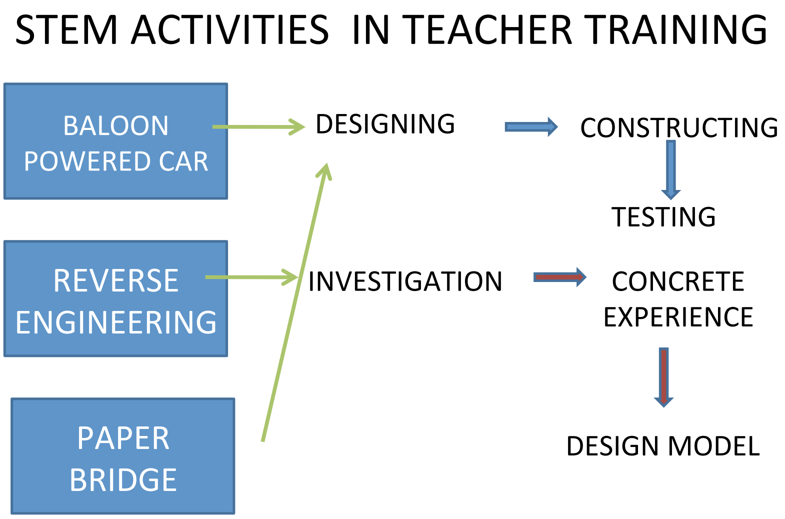


Figure 3.5 Schemes of STEM Activities in Teacher Training

Facing limitation of STEM knowledge, college collaboration, and school curriculum policy, it was decided to use other methods of implementation for the next school term semester. Project Based Learning (PBL) was taken as an approach of implementation. First and second grades students were challenged to compete in making solutions for flood disasters that always happen every rainy season in Indonesia. Students were asked to write a proposal of their solution designs that would be judged for its feasibility by teachers. Students with selected proposal continued their projects and showed the weekly progress reports to teachers. Finally, students' project results were presented and selected for joining the STEM Summer Camp poster session in Yaizu Japan. These activities aimed to enhance students' interests and knowledge of STEM education and career.
Scheme for implementation methods in the second semester is shown in figure 3.6.

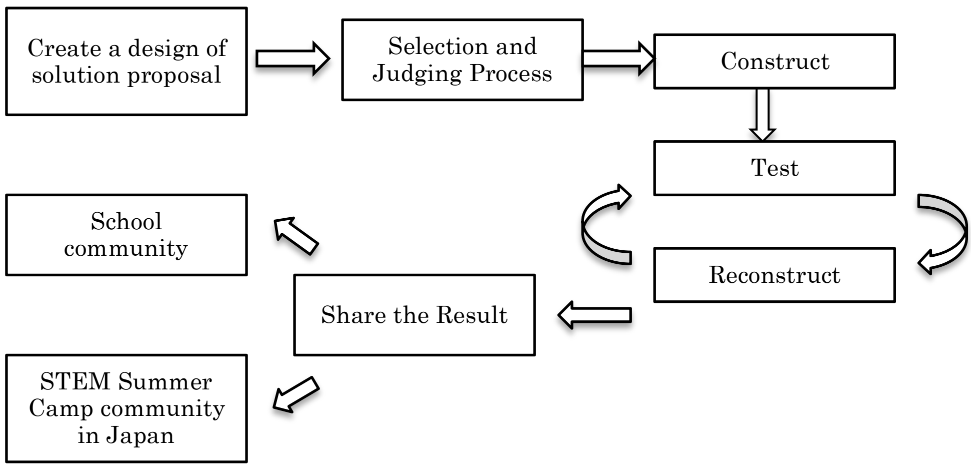


Figure 3.6: Diagram of STEM Education Implementation Method of Second Semester in Indonesia

INSTRUMENT AND DATA ANALYSIS FOR RESPONDING TO RESEARCH QUESTION 1

Q.1.1 Multiple intelligences profile in university level

In undergraduate level, self-report assessment that uses for this research was Multiple Intelligences Survey that developed by Walter McKenzie (1999). The survey measured nine intelligences. Students had to determine whether they agree with each statement in the survey. If they were in agreement with the statement,

they put '1' beside the statement. If they did not agree, they left it blank. The questionnaire survey composes of nine sections ask 10 statements refer to each intelligence characteristic. The score for each section was calculated and multiplied by 10. If a student's score was between 0-25, it was categorized as "not advanced". Scores of 26-50 were categorized as "advanced". Those of 51-75 were categorized as "intermediate advanced" and those of 75-100 as "very advanced" (see Appendix B 1.a). The results were analyzed using ANOVA to statistically test the differences among intelligence area for each group.

Q.1.2 Multiple Intelligences profile in middle school level

In middle and elementary student level, self-report assessment that uses for this research was "How Many Intelligences are You dominant" adapted from Laura Candler (Teaching Resources at http://home.att.net/~teaching, 2011) (see Appendix B.2a-2b). This questionnaire consisted of 21 statements that measured seven intelligences areas. The score for each section was calculated and multiplied by 10. If a student's score was between 0-25, it was categorized as "not advanced". Scores of 26-50 were classified as "advanced". Those of 51-75 were classified as "intermediate advanced" and those of 75-100 as "very advanced". The results were analyzed using ANOVA to statistically test the differences among intelligence for each group of student.

Q.1.3. Differences of MI profile at the beginning and the end of semester

Class observation in a junior high school in Japan and Indonesia was conducted to analyze differences of multiple intelligences profile in one semester. The observation sheet developed into several columns that observed class activities, teacher question, student response, and trained intelligences, which divided into phases 1 to 3 (see Appendix B.4). The results were analyzed using ANOVA to statistically test the differences.

INSTRUMENT AND DATA ANALYSIS FOR RESPONDING TO RESEARCH QUESTION 2

Q.2.1.STEM education implementation in 2013 summer camp

Q.2.1.1 Student knowledge before and after STEM Camp

Students were asked to make a mind map of *tsunami*, this activity can measure student's knowledge and way of thinking (see Appendix C.1.1). This rubric was adapted from Cronin P.J, Dekker J. Dunn (1982).

Q.2.1.2 Analyzing MI Profile and Its Characteristic

To analyze consistency of students MI profile to its characteristic, an observation sheet was adapted from Connie Hine (Excelligence Learning Cooperation, 2008). Observer checked the characteristic of students in each group that has been divided based on their dominant intelligences. It consisted of 54 statements that described eight intelligences characteristics (see Appendix B.3a-3b). Data were scored and analyzed the reliability statistically.

Q.2.1.3. Assessing creativity skill

Creativity skill assessed from a mind map that made by the students. This part was challenging in term of objectivity of judgment. Creativity orientation asserted areas were fluency, flexibility, originality, elaboration, abstractness and resistance to premature closure. It was constructed in a matrix of creativity to assess creative thinking (see Appendix C.2.2). Data were scored and analyzed descriptively.

Q.2.1.4. Analyzing STEM education challenges

Challenges analysis divided into two categories:

- The challenges of implementation engineering and technology to the activities assessed with rubric of STEM summer camp project that adapted from rubric for STEM Learning Environment developed by Sangueza, C., 2012. Rubric consisted of four categories; exemplary, implementing, emerging, and Non-STEM. The elements are Integration of science and mathematics, technology, engineering design, STEM professionals, link to career, what students were doing and autonomy (see appendix D.1).
- Using context of STEM, it evaluated the issues in STEM context, whether or not it was in a central position and uses the four disciplines of STEM to

understand and address the problem. It was evaluated based on rubric that adapted from Bybee (2013).

Q.2.2. STEM education implementation in 2014 summer camp

Q.2.2.1 Student knowledge before and after STEM camp

Students were asked to make a concept map of *natural disaster*. This activity can measure student's knowledge and the way of thinking (see Appendix C.1.1). This rubric was adapted from Novak, J. D., & Gowin, D. B. (1984). Based on last year result, a puzzle (see Appendix C.1.2) game approach was added in making concept map processes. It guided student's thinking in delivering their idea into a concept map. The differences were analyzed using Mean Whitney U test.

Q.2.2.2. Analyzing MI Profile and Its Characteristic

MI profile was adapted from TC publication "The Multiple Intelligences Quiz" that measured eight intelligences areas by giving eight statements for each area (see Appendix B. 2c-2d). Students asked to choose a number between 1-5 for each statement to rate how the statement describes them. Significance of difference in MI profile before and after camp activity was measured by the Wilcoxon rank test. Observation sheet of MI characteristic was the same, but it delivered based on activities that reflect from each intelligence area (see appendix. B.3c). Consistency of MI profile and its characteristic were described by comparison diagram.

Q.2.2.3. and Q.2.2.4 Assessing creativity skill

It was not only solution design that analyzed in this camp, but also creativity skill profile before and after STEM camp. TTCT (Torrance Test of Creative Thinking) was used to measure student creativity skill profile (see appendix B.5a-b). Data scored based on rubric that adapted from NRC (2010) (see. appendix C.2.1&2.3), and analyzed the differences using Wilcoxon Rank Test.

Q. 2.2.5 Assessing students' response to STEM education implementation

Students' response to STEM education implementation was collected through STEM Implementation Questionnaire that asked students' interest, agreement, and perception of STEM education and career (see. appendix B.4a-b). The differences before and after camp activity, was analyzed by dependent samples t-test statistically.

Q.2.2.6 STEM education implementation challenges

The same evaluation instruments were used in this study. It only evaluated two categories; the challenge to implement T and E, and using context of STEM (see appendix D.1 and D.2).

Q.2.3 STEM Education Implementation in Indonesia

Q.2.3.1 Analyzing Indonesia Curriculum

To know whether or not STEM education can be embedded into curriculum that uses in school, an instrument that adapted from Bybee (2013) was used. It consisted of three table of curriculum content analyzes; 1) analyze the content that can invite two STEM disciplines integration (SM, ST, SE, MT, ME, TE); 2) analyze the content that can invite three STEM disciplines integration (STE, SEM, TEM, MTS); and 3) analyze content that can invite all STEM disciplines. All data analyzed descriptively.

Q.2.3.2 Teacher Response and Perception

To measure teacher attitude toward STEM education, their responses were collected using Likert type items and semantic difference questionnaire. The *STEM Semantic Survey* (SSS) (see appendix B.6) identified teacher`s response and perceptions related to their interest, knowledge and STEM training reflection. Likert type items were identified as a single question that uses some aspects of the original Likert response alternative (Clason & Domody: Boone, 2013). The items collected the data in ordinal score, thus the analysis process takes descriptive statistic method. Data was scored and analyze descriptively. Analysis method of teacher perceptions toward disciplines and STEM career was adopted from Berlin & White (2010). It was scored 5, 4, 3, 2, and 1 for positive directed word pairs (e.g. exciting-unexciting), and 1, 2, 3, 4, and 5 for negative directed word pairs (e.g. mean nothing-mean a lot). Feasibility perception was scored differently. It was recoded to assign a number 5 to responses reflecting the most realistic attitude and perception related to the implementation of integration in the classroom. For pair "simple-complicated", the remaining recodes were distributed so as to account for slightly higher scores for attitudes and perceptions related to challenges associated with integration (1 3 5 4 2). For pair "slow-fast", it is encoded (2 4 5 3 1). For pair "hard-easy", it is encoded (2 4 5 3 1).

Q.2.3.3 Teacher Self-Reflective

Teachers' self-reflective was collected through journal that consists of three questions: what did you learn, what problem did you face, and how did you solve the problem. It was scored based on the rubric of self-reflective assessment that assessed teachers' understanding; define problem skill, and problem solving skill. Its differences in every STEM activities were analyzed using non-parametric Kruskal-Wallis formula.

Q. 2.3.4 Implementation in Learning Process

a. Student Response: Interview analyses have been taken to measure learning impact for student, whether or not they enjoy the learning process, what problems their faced, and what solution they took to solve problem.
b. Comparing implementation result: students' achievement and MI profiles were compared and analyze statistically.
c. Analyzing students' creativity from solution design toward 'flood' issues. It measure based on creativity rubric that adapted from NRC 2010.

Q.2.3.4 STEM Education Implementation Challenges

The same evaluation instruments were used in this study. It only evaluated two categories; the challenges to implement T and E, and using context of STEM (see appendix D.1 and D.2).

Table 3.1: Summary of Research Instrument and Analysis Method

Question	Instrument	Analysis method
Comparison of Multiple Intelligence Profile	Multiple Intelligences Survey (McKenzie, 1999)	Scored and ANOVA
Students' knowledge	Mind Map Rubric Concept Map Rubric	Scored, and t-test Scored, Mann Whitney U-test
Comparison of creative thinking skill profile	Torrance Test of Creative Thinking	Scored and Wilcoxon Rank Test
Creativity skill	Creativity Rubric	Scored, analyze descriptively, Wilcoxon rank test
Curriculum analyses	Table of analysis	Analyze descriptively
Teacher attitude (response)	- Likert-type questionnaire - Semantic different questionnaire	Scored, analyze descriptively, t-test, non-parametric Kruskal-Wallis
Student attitude (response)	- Interview - STEM implementation questionnaire	Scored, analyze descriptively
Implementation challenges evaluation	Evaluation Rubric	Compared Qualitatively

CHAPTER IV
PRESENTATION OF RESULTS

INTRODUCTION

The results of observation and experiment are reported in this chapter. There are two main sectors that respond to research question 1 and research question 2. First sector reported the descriptive research results of multiple intelligences profile of undergraduate and middle school students in Japan and Indonesia. The differences results of MI profile in both countries were compared and analyzed. It supports previous researches about cultural diversity that influences the self-estimate of intelligences. It became basic research consideration of STEM education implementation in both countries. The second sector reported the experiment research results of STEM education implementation in Japan and Indonesia that were divided into three main focus areas: student's knowledge, MI profiles and its characteristics, and creativity skills. Students' knowledge analyzed from two different data sources; a) students' concept map, through STEM education activities of STEM Summer camp in Japan, and b) students' achievement tests of science learning, through STEM education learning in Indonesia. MI profiles were collected in both implementation using same instrument, and creativity skill was measured from students' design of solutions in STEM education activities. Furthermore, analyses of challenges of engineering and technology implementation, and the using of STEM context in Japan were compared to Indonesia. They would be a consideration for further STEM education implementation research.

MULTIPLE INTELLIGENCES PROFILE STUDY

A novel in neuroscience about intelligence brought new paradigm in education. The traditional paradigm viewed intelligence as a unitary of brain capacity that could be measured by IQ test. In contrary, Howard Gardner defines intelligence as *bio-psychological potential to process information that can be activated in a cultural setting to solve problems or create products that are valued in at least one culture*. He suggested that every human possesses at least seven independent abilities or intelligences. They are Linguistic/Verbal (V-I),

Musical-Rhythmic (M-R), Logical Mathematical (L-M), Visual-Spatial (V-S), Bodily Kinesthetic (B-K), Social Interpersonal (S-I) and Intrapersonal (I-I) Intelligences. Later, he added Naturalist and Existential Intelligences (Gardner & Hatch, 1989). In this theory, intelligence examines as *composites of fine-grained neurological sub-processes but not sub processes themselves, as bio-psychological information processing capacities, and as the bases on which an individual can participate in meaningful activities in the boarder cultural miles* (Gardner and Moran, 2006).

Gardner (1999) argued that every human have at least seven independent intelligences but only have one or two dominate intelligences and all of them are influenced by environment. Some researchers study about student profile to support the theory. Gunes (2010) showed that there was a meaningful difference in four intelligences types (interpersonal, bodily kinesthetic, spatial, and naturalist) of the graduate students educated at Secondary Science and Mathematics Education (ME), Computer and Instructional Technologies Education (CITE). It was also concluded that within interpersonal, bodily kinesthetic, and naturalist intelligences profile in science education domain, student were more advanced than the students in mathematical education domain. On the other hand, spatial intelligences types of CITE students were more developed than the graduate students in ME domain. Other research showed that logical mathematical intelligence was the most developed intelligences both in male and female students of physics department of Secondary Education Science and Mathematical Branches of Education Faculty in Selcuk University (Guzel, 2010).

MI theory attracted some education researchers to study MI in Japan. For instance, Miler (2009) studied about successful teaching strategies that targeted the visual, tactile and kinesthetic learner in order to motivate and engage a greater portion of students in the Japanese EFL (English as Foreign Language) classroom. He suggested that a combination of strategies should be introduced into the classrooms that cater for the tactile and kinesthetic learner without alienating Japan's traditional base of visual learner in the classrooms. In this study, he took the dominant intelligence profile of students as a guide to create new teaching strategies and they can trigger student motivation in learning English as a foreign language. Other research studied about multiple intelligences among Japanese parents and their children (Furnham, 2008). It showed that Japanese parents'

self-estimate were lower than those found in western population, and male (fathers) rated their own multiple intelligences, significantly higher than did female (mothers). This shows a distinct cultural norm in Japan. Those results showed that Japanese tended to show humility in their self-estimation. They thought that humility is related to efforts and perseverance, and they believe that effort is a road to success. Shimizu (2001) said that Japanese have their own 'cultural concepts' that guide their social behavior.

In Indonesia, MI theory was used as one of the approaches in science learning processes to reach goals of education, referred to KTSP (curriculum based on education unit level). The curriculum emphasized on giving direct experience through scientific inquiry to improve the competence in understanding a nature scientifically. This competence became basic of curriculum development in each unit (schools). Student diversities became a consideration for educators in creating curriculum; each region had its own culture, so that MI theory could be one of the solutions of the problems.

Furthermore, students' multiple intelligences profile could be a basic of thinking for teachers in deciding the learning methods and strategies. Teacher could create a strategy based on student dominant intelligences. For instance, Campbell (1992) took the idea of pattern existing everywhere, she help students to discover this in order to bring mathematical alive and developed students' logical and mathematical intelligence. Students asked to recreate designs in nature using straight edges, compass and protractors. The lessons could be delivered in many ways depending on students' intelligences profile so that student could master it easily.

According to those assumptions, the MI profiles of science student was studied to investigate the dominant and least intelligences area, and then to analyze its differences statistically. The two countries are in the same area but in different regions, weathers and cultures. Did students have same pattern in theirs intelligences?

Comparison of Multiple Intelligence Undergraduate Students' Profile in Japan and Indonesia: An Undergraduate Mathematics and Science Student's Differences in Logical Mathematical Intelligence Area

The aim of this research was to determine the multiple intelligence profiles of

science students in Japan compared to science students in Indonesia majoring in physics, chemistry, biology, mathematics, computer science, science education and geology to determine what was the most and the less developed intelligences, and then to analyze the differences in logical mathematical intelligences. Samples of this research were science and science education students in both countries, in Indonesia (N=492) and Japan (N=62). Japanese samples were undergraduate students who had been taking chemistry, biology, physics, and geology and science education major. The data were gathered with Multiple Intelligence Survey that was developed by Walter McKenzie and was translated into Japanese and Bahasa Indonesia. The significant differences in every intelligence area were analyzed with ANOVA.

Methodology: The multiple intelligence profiles of the students were determined with a translated version of the multiple intelligence survey developed by Walter McKenzie in 1999. The survey measures nine intelligences. Students have to determine whether they agreed with each statement in the survey. If they were in agreement with the statement, they put '1' beside the statement. If they do not agree, they leave it blank. The questionnaire survey consists of nine sections, which ask 10 statements refer to characteristics the intelligences. The score for each section was calculated and multiplied by 10. If a student's score was between 0-25, it was categorized as "not advanced". Scores of 26-50 were categorized as "advanced". Those of 51-75 were categorized as "intermediate advanced" and those of 75-100 as "very advanced".

Null hypothesis 1: there is no difference in MI profile between Japanese and Indonesian undergraduate student.

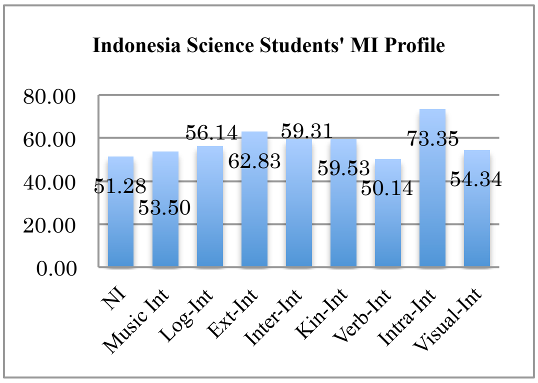
Research Questions:

- Which intelligence is most developed among science students in each country?
- Which intelligence is different significantly among science students in Japan?
- Which intelligence is different significantly among science students in Indonesia?

Result:

The charts below were resulted from multiple intelligences survey, which was given to students. They put their agreement in each statement then it was scored

ranged from 0 -100. It showed that student in both countries reach high scores in intrapersonal intelligence. It meant that they had the same most developed intelligences whereas Indonesia scores (73.35) higher than Japanese (62.18). The less developed intelligence for Japanese student was musical intelligence (38.19) while for Indonesia student was verbal intelligence (50.14).



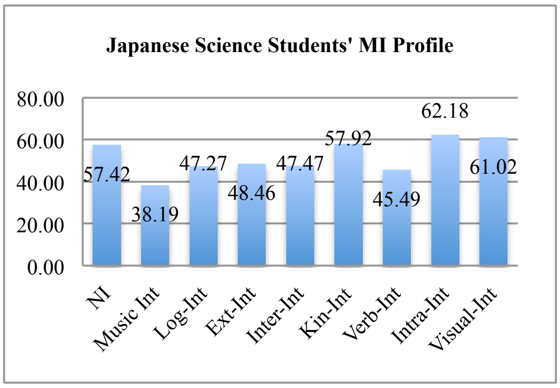


Figure 4.1: Multiple intelligence profile of science and math student in Indonesia and Japan

Intrapersonal intelligence *is ability to understand oneself, to appreciate one's feelings, fears and motivation. It involves having an effective working model of us, and is able to use such information to regulate our lives* (Gardner, 1999). One of job field that need this intelligence is researcher, novelist and entrepreneur. The student in both countries were most developed in this intelligences, they were in advance level. Although Indonesia students' score were higher than Japanese, the differences of this intelligence were not significant statistically.

Musical intelligence *is ability to like music, to melodize, to remember melodies, to recognize sounds. It involves skill in performance, composition, and appreciation of musical patterns. It runs in almost structural parallel to verbal-linguistic intelligence* (Gardner, 1999). Japanese science student were least developed in this intelligence. They were in advance level while Indonesia science student were in intermediate advance level. Indonesia science students' score is higher than the Japanese and it was different significantly. It showed that Indonesia science student had more interest in music than the Japanese.

Verbal Linguist intelligence was the less develop intelligence for Indonesia science students. It *is ability to use mother or foreign language, to communicate by reading, speaking, writing and listening, express opinion and to understand other people*. Indonesian language subject was less interesting than science

subject for them so that theirs verbal intelligence were in lower scores than other intelligences. In Japanese science students, this intelligence also reached low score (45.49) but it was higher than musical intelligence score. Comparing to Indonesian science student, their intelligence score was lower but it was not different significantly. It showed that in both countries this intelligence was not developed well.

Table 4.1: ANOVA of intelligences scores in each major of Japanese science students.

Intelligence		Sum of square	df	Average of Square	F	F_{cv}
Naturalist	Between	2465.30	4	616.32	1.38	2,37
	Within	25470.19	57	446.85		
	Total	27935.48	61			
Musical	Between	1520.52	4	380.13	1.06	2,37
	Within	20479.48	57	359.29		
	Total	22000.00	61			
Logical-Math	Between	3406.28	4	851.57	2.89	2,37
	Within	16813.08	57	294.97		
	Total	20219.35	61			
Existential	Between	730.46	4	182.62	0.43	2,37
	Within	23974.38	57	420.60		
	Total	24704.84	61			
Social-interpersonal	Between	485.27	4	121.32	0.28	2,37
	Within	24353.44	57	427.25		
	Total	24838.71	61			
Physical-Kinesthetic	Between	777.07	4	194.27	0.32	2,37
	Within	35011.64	57	614.24		
	Total	35788.71	61			
Verbal-Linguistic	Between	1808.27	4	452.07	1.64	2,37
	Within	15746.57	57	276.26		
	Total	17554.84	61			
Intrapersonal	Between	8548.43	4	2137.11	4.56	2,37
	Within	26728.99	57	468.93		
	Total	35277.42	61			
Visual-Spatial	Between	2171.75	4	542.94	1.06	2,37
	Within	29112.12	57	510.74		
	Total	31283.87	61			

Based on ANOVA of intelligence score in each science major for both countries (Table.4.1 and Table.4.2), they were significant different in Logical Mathematical and Intrapersonal Intelligence for science student in Japan, while in Indonesia the differences found on Naturalist, Logical Mathematical and Visual Spatial Intelligence. Based on those facts, it can be concluded that logical

mathematical intelligence was different in each science major of both countries. This intelligence showed students ability in logical and critical thinking. It described student ability in solving problem were different for each major. The average score of logical mathematical Intelligence for science student in Japan is 47.27, while Indonesia science students reach higher score in this area (57.17).

Table 4.2: ANOVA of intelligences score in each major of Indonesian science students

Intelligence		Sum of square	df	Average of Square	F	F_{cv}
Naturalist	Between	4305.68	4	1435.23	5.49	3,02
	Within	127498.39	487	261.27		
	Total	131 804.07	491			
Musical	Between	1233.39	4	411.13	1.76	3,02
	Within	114123.32	487	233.86		
	Total	115 356.71	491			
Logical-Math	Between	3991.37	4	1330.46	5.30	3,02
	Within	122534.65	487	251.10		
	Total	126 526,02	491			
Existential	Between	314.09	4	104.698	0.410	3,02
	Within	124471.27	487	255.06		
	Total	124785,36	491			
Social-interpersonal	Between	1717.92	4	572.64	1.84	3,02
	Within	152092.45	487	311.66		
	Total	153810,37	491			
Physical-Kinesthetic	Between	2806.72	4	935.57	2.70	3,02
	Within	169385.97	487	347.10		
	Total	172192,69	491			
Verbal-Linguistic	Between	1073.62	4	357.87	1.08	3,02
	Within	161845.08	487	331.65		
	Total	162918,70	491			
Intrapersonal	Between	887.017	4	295.67	1.38	3,02
	Within	104406.27	487	213.95		
	Total	105293,28	491			
Visual-Spatial	Between	6005.89	4	2001.96	5.26	3,02
	Within	185884.15	487	380.91		
	Total	191890,04	491			

The average score of logical mathematical intelligence for each science major in both countries can be seen in Table.4.3. It showed that the highest score got by physics student in Japan while in Indonesia it was reached by mathematics students. Japanese science educations students reached the lowest score of this intelligence, and biology students in Indonesia reached it. Furthermore, all sample

of Indonesian science and mathematics student were in intermediate advance level but only Japanese physics students were in this level. This result are surprising, as it is known that Japan as a developed country which is famous in its technology development. It is also found by Furnham (2008) that Japanese student estimations of their own MI are lower than other countries. In other countries indicate that parents and students believe their overall and multiple intelligence to all be well above the mean. This shows a distinct culture norm toward modesty in Japan.

The result that showed in tables indicates that null hypothesis (1) can be rejected. Japanese and Indonesian student have some differences in estimating their intelligences. They differ in less developed intelligences, and similar in logical mathematical intelligences area. It was the most different significantly among students of each major, even though compare to Indonesian, Japanese students have lower score. This was intriguing and unexpected result, because it was assumed that students from Japan, as a technology oriented country and more developed than Indonesia, have higher self-estimated score than Indonesian.

These facts show that even though they are Asian but they have different way to define the intelligences. Lynn (1982, 1993) said that Japanese are the most self-deprecating about their intelligence despite there being ample evidence of their overall high ability on test.

Table 4.3: Average score of logical mathematical intelligence

Japan					Indonesia				
Physics	Biology	Chemistry	Geology	Science Education	Physics	Biology	Chemistry	Math	Computer science
56.36	43.33	46.67	42.73	34.73	56.19	51.27	52.03	61.03	54.73
Intermediate advance level	Advanced level				Intermediate advance level				

<u>Comparison of Multiple Intelligences Profile in Japanese and Indonesian Middle School Students</u>

The aim of this research was to identify the multiple intelligence profile of middle school student in Japan and Indonesia, to analyze what were the most and less developed intelligences, and to compare the differences of each intelligence area

in both countries. Samples of this research were 40 Fuzoku-Japan middle school students and 100 Cikarang-Indonesia middle school students. The school sample was chosen purposively in term of research area limitation. Fuzoku Junior High School affiliated to the Faculty of Education Shizuoka University, which located in Shizuoka-Shi. The data were gathered using Multiple Intelligence Survey that was developed by Walter McKenzie (1999) and was translated into Japanese and Bahasa Indonesia. The significant differences in each intelligence areas were analyzed with t-test.

Methodology: Same as previous research in undergraduate level, multiple intelligences profile were collected using a translated version of the multiple intelligence survey developed by Walter McKenzie in 1999. The survey measures nine intelligences. Students had to estimate whether or not they agreed with each statement in the survey. If they agreed with the statement, they put '1' beside the statement. If they did not agree they will leave it blank. The questionnaire survey consisted of nine sections, which ask 10 statements refer to characteristics the intelligences. The score for each section was calculated and multiplied by 10. If a students' score was between 0-25 it was categorized as "not advanced". Scores of 26-50 were categorized as "advanced". Those of 51-75 were categorized as "intermediate advanced" and those of 75-100 as "very advanced".

Null hypothesis 2: there is no difference in multiple intelligences profile between Japanese and Indonesian middle school students.

Research questions:

- Which intelligence that most developed/ dominated among middle school students in each country?
- Which intelligences that different significantly among middle school students in both countries?

Result:

The average score of self-estimate in each area determined which intelligence area that most or less developed in each country. Furthermore, to analyze how the scores were differed in both countries, t-test for independent sample where $\sigma_1 \neq \sigma_2$ was selected to analyze the intelligences average score differences

statistically. In this procedure, the standard error of difference was estimated differently and the degrees of freedom used to test the hypothesis were adjusted using Satterthwaite, Cochran and Cox formula. The results were shown in diagram and table 4.5 below.

The diagram describes self-estimate result of middle school student in Indonesia and Japan. It showed that Indonesian middle school students were most developed in Intrapersonal Intelligences (II) and they were less developed in verbal-linguist intelligence (VL). On the other hand, Japanese middle school students estimated that they were most developed in body-kinesthetic intelligence (BK) and were less developed in logical-mathematical intelligence (LM). Indonesian students were in “advanced” level for verbal-linguist intelligence (VL), while Japanese students reached the `advanced’ level for naturalist intelligence (NI), logical-mathematical intelligence (LM), existential-intelligence (EI), social interpersonal-intelligence (SI), and verbal-linguist intelligence (VL). Furthermore, Indonesian students were in “intermediate advanced” level for NI, LM, MR, EI, SI, BK, II and VS (visual spatial) intelligences, while Japanese students achieved this level for MR, BK, II and VS intelligences. These were an unexpected result, because it was assumed that Japanese student will score their logical mathematical (LM) and naturalist (NI) intelligence higher than Indonesian students.

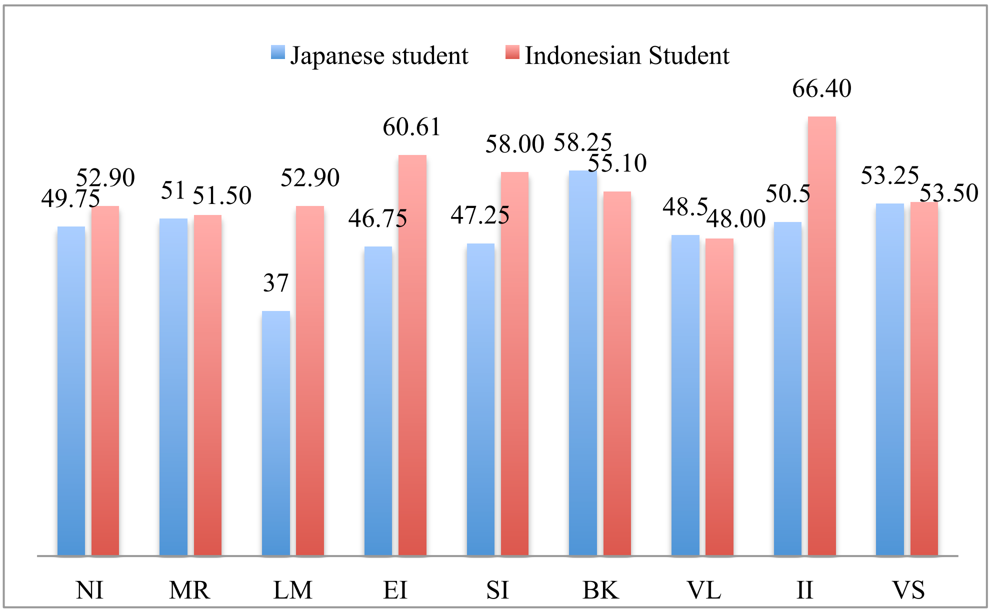


Figure 4.2: Profile Diagram of Middle School Students’ Multiple Intelligences (MI) Score

Table 4.5 below shows differences in intelligences that analyzed statistically to convince whether or not it was differ significantly. For these data with degree of freedom (df) range from 60-100, the critical values (t_{cv}) was $\pm$ 2.660 at α = 0.01. Thus, by using Cochran and Cos/Satterthwaite procedure, it was founded that the observed value ($t_{obvalue}$) of logical Mathematical (LM), Existential intelligences (EI), Social Interpersonal intelligence (SI) and intrapersonal intelligences (II) were exceeded the t-cv. Thus, this result indicated that null hypothesis (2) was rejected. It concluded that Japanese students estimate their logical mathematical, existential, social interpersonal and intrapersonal intelligences lower than Indonesia significantly.

Table 4.4: Level of Multiple Intelligence Profile

Student	Japanese middle school student								
Area of intelligences	NI	VL	LM	EI	SI	BK	MR	II	VS
Average score	49.75	48.5	37	46.75	47.25	58.25	51	50.5	53.25
Level	Advance					Intermediate advance			
Student	Indonesian middle school student								
Area of intelligences	NI	MR	LM	EI	SI	BK	VS	II	VL
Average score	52.9	51.5	52.9	60.61	58	55.1	53.5	66.4	48
Level	Intermediate-advanced								Advanced

Table 4.5: Mean, t-test for multiple intelligences self-estimate score of Indonesia and Japanese students

MI Area	NI	MR	LM	EI	SI	BK	VL	II	VS
Mean of Indonesian	52.9	51.5	52.9	60.61	58	55.1	48	66.4	53.5
Means of Japanese	49.75	51	37	46.75	47.25	58.25	48.5	50.5	53.25
t_{value}	0.982	0.121	4.583	3.680	2.857	-0.788	-0.127	4.289	0.060
df	74	51	72	66	64	72	62	66	75
t_{cv}	2.660	2.660	2.660	2.660	2.660	2.660	2.660	2.660	2.660

p >=0.05

Science Learning Observation at Middle School in Japan Based on Science Technology Engineering and Mathematics (STEM) Education and Multiple Intelligences (MI) Views: Impact of Learning Process to the Multiple Intelligences Profile

Gardner's theory of multiple intelligences has been facing critics (Waterhouse, 2006) among psychologist since it was issued on 1983 through a book *Frame of Mind*. They had accepting "*g*" intelligences theory by Spearman (1927), and arguing the intelligence definition of Gardner (1989). Gardner (1999) explained that he reviewed hundreds of studies before publishing *Frames of Mind*, and that he assessed all candidate intelligences on the basic of eight criteria: the potential of isolation by brain damage; an evolutionary history and evolutionary plausibility; an identifiable core operation or set of operation; susceptibility to encoding in a symbol system; a distinct developmental history; the existence of savant, prodigies, and other exceptional people; support from experimental psychological tasks; and support from psychometric finding. Furthermore, he stated that his choice of the word "intelligences" was a deliberate one, noting that if he had written a book referring to "faculties" or "gifts," it was unlikely that his theory would have garnered the attention that it has.

Surprisingly, this theory more accepted by educator. Gardner (2011) stated that "*no educational implication follow directly from this psychological theory, but if individuals differ in their intellectual profiles, it makes sense to take this fact into account in devising an educational system for individuals, groups or even nation"*. Gardner messaged that children has unique and diverse abilities meshed well with educator's initiative sense that children learn in very different ways. He added "*when one had a thorough understanding of topic, one could typically think of it in several ways, thereby making use of one's multiple intelligences. Conversely, if one was restricted to a single mode of conceptualization and presentation, one's own understanding was likely to be tenuous"*.

Multiple intelligences are independent and need to be combined together in solving problems to get the knowledge. It can be developed and trained based on the intelligences that more needed on solving problems. Many works need to be done on the question of how the intelligences can be best mobilized to achieve specific pedagogical goals. However, some teachers ignore this theory and more focus on how to deliver a matter concept to students without considering how student master the concept. They are ignoring students' intelligences diversity and

thought that all students have similar way in getting their knowledge. It was assumed that the result would not show all students achieve the learning goals. Somehow, they were not realized that they trained and developed several areas of intelligence to the students through the instruction. *Good teacher had been instinctively catering to different intelligences without even knowing of the MI model* (McKenzie, 2005).

In Japan, multiple intelligences theory got limited responses from teachers and researchers. Science education in Japan has been emphasized on enhancing science and technology. It is essential to improve science literacy among the public and to foster human resource for science and technology. Thus, most teachers are emphasizing science learning to be integrated with technology. Therefore, schools were collaborated with other institution (science museums or science center) to conduct some projects in order to enhance it.

On the other hand, STEM educations are developing in other countries such as the US, the UK, Australia, Thailand and Korea. This has been developing to solve the lack of students' interests in science that impact to the lack of innovation and development in science and technology. In 2003, the average of Japanese students' achievement in PISA scored was 534 on math literacy and 548 on science literacy, these scores was better than the US. These facts were raised question: how was science learning process in Japan that could make Japan students' score was higher than the US. Integrated technology to the science learning process was one perspective of STEM education implementation. Thus, how they integrated technology into learning process became one of research questions in this study.

So the aims of this study were to observe learning process in one semester by investigating trained intelligences area and STEM integrated approached that used in the learning process. Especially to analyze the impact of learning process to students' multiple intelligences profile by calculating the different statistically and to observe variety of STEM integration in the teacher instructions by dividing learning process into three main phases; 1) engagement, 2) exploration through an experiment, and 3) discussion through a result presentation.

Methodology:

The study was conducted in *Fuzoku* Junior High School, which affiliated to Faculty of Education Shizuoka University, which is located in Shizuoka-Shi.

There were four classes for each grade and consist of 40 students, and a third grade class was taken. It consists of 20 female and 17 male students. This was a purposive sample, to study about physics lesson that will be delivered for 3 months in this class. The lesson conducted in science class that designed as a science laboratory. The scheme is illustrated in figure below:

Teachers' table

students' desk

students' desk

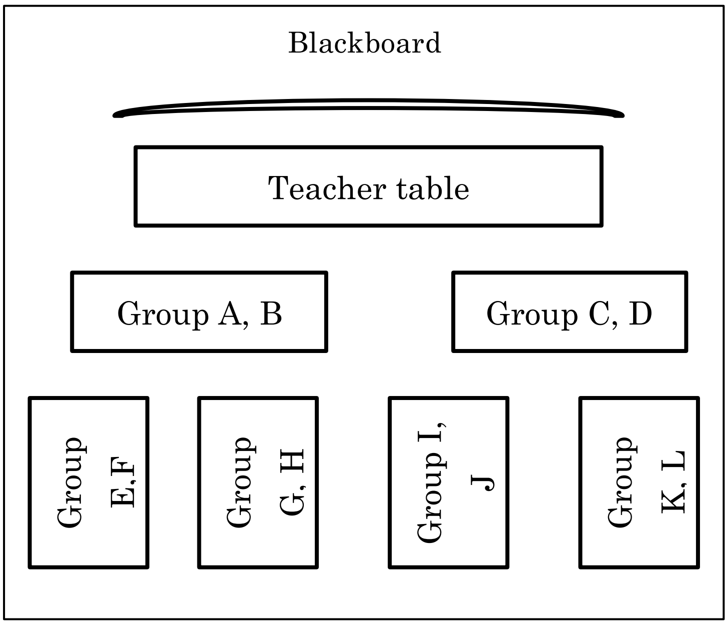


Figure 4.3: Students Room Scheme

Learning processes observed by identifying teacher instruction refer to trained intelligences area and STEM integration approached. Students' multiple intelligences (MI) profile was taken with the multiple intelligence survey developed by Walter McKenzie in 1999. The average score of MI profile before and after lesson in one semester was analyzed with t-test for dependent sample.

<u>Null hypothesis 3:</u> a. There is no significantly different on students' multiple intelligence profile before and after learning processes in one semester.

b. There are no various STEM integrations in learning process.

<u>Research Questions:</u>

- What is the impact of learning process to the students' multiple intelligences profile?

- What kind of STEM integration that occurred in learning process?

Result

Term of STEM education and multiple intelligences were quite different for teacher. In this case, STEM referred to science and mathematics. This perspective should not be surprising because of long history of these disciplines as a circular component.

Table 4.6: The Observation Result

Date	**Activity**	**Teacher question**	**Student Response**	**STEM Integration**	**Trained Intelligence**
23-5-2013	**Topic:** Free fall **Durations**: 1 hour **Goals:** To understand the concept of free fall. **Method**: Demonstration, discussion				
	Phase. 1, 2, & 3(This time learning process conducted independently by students)				
	Activity: student analyzed the phenomena of free fall from different metal ball.	Do they have the same fall time? Why?	Some student works in groups they take the balls and conduct their own investigation helped by books. The rest of students are going to library and study there.	Science and Math	Logical mathematical Verbal linguist
31-5-2013	**Topic:** Work **Duration**: 1 hour **Goals**: To understand the concept of Work. **Method**: Experiment, Demonstration, Discussion				
Phase 1.					
	Engagement activity: Teacher gave phenomena from baseball stick. Teacher hold the bigger side of baseball bat then asked a student to rotate the smaller side.	What did happen when smaller side is rotated? Why did the smaller side hard to rotate?	Students see that the smaller side hard to rotate.	Science	Logical mathematical

Table 4.6: Continued

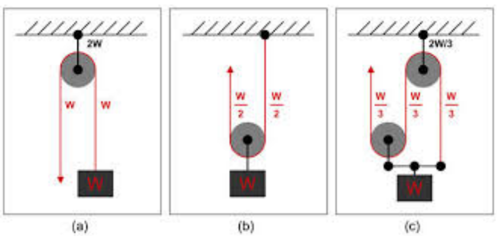
Date	Activity	Teacher question	Student Response	STEM Integration	Trained Intelligence
	Phase 2.				
	Exploration: Teacher give plastic bottle to each group then asked them to do the same activity	What did happen? Why did it happen?	Students conducted experiment of the bottle and find the answer from book and other source.	Science	Logical mathematical Bodily kinesthetic
	Phase 3				
	Discussion: Teacher asked student to explain their answer. Teacher gave other demonstration. He moves the basket on table, then asked	Does stick length work on the force? Did the basket do work? Can you explain what work is?	Only two students (1 girl and 1 boy) active in responding teacher question: A student said that the application of this concept could be seen in the gear. The bigger gear will move first than the smaller one. The other students said the application is in bicycle. Work is number of forces that work on object to move. W – F x s	Science, Mathematics and Technology	Logical mathematical Verbal intelligences Visual spatial
3-06-2013	**Topic:** work Duration: 2 hours **Goals:** to understand work and energy **Method**: demonstration, experiment, discussion				
	Phase 1				
	Conduct experiment of pulley to study 'Work' concept	What was learned last week Draw the pictures (a) and (b) bellow:	Prepare the experiment	Science, Mathematics and Technology	Logical mathematical Visual spatial
			Which one is lighter/heavier between (a) and (b)?		

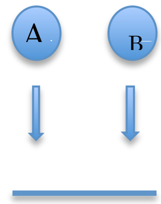
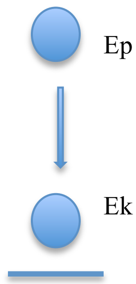
Table 4.6: Continued

Date	Activity	Teacher question	Student Response	STEM Integration	Trained Intelligence
	Phase 2				
			Students conduct the experiment: Material: - Rope - Single Pulley - Double pulley - Spring balance - Stand rod kit.	Science and Mathematics	Logical mathematical Body kinesthetic Verbal linguistic
	Phase 3				
	He connected one dynamo to another dynamo and then rotated it. He rotated first dynamo for ten times and asked student to count the second dynamo rotation. Second dynamo rotated 8 times only. He asked students to find the answer for 20 minutes from book or other source. Student may go to library.	Why the work seems easier?	After 20 minutes, some students argue that there is some energy, which is transferred to another form of energy	Science	Logical mathematical
12-06-2013	**Topic**: Energy Conservation Duration: 2 hours **Goals:** to understand work and energy **Method**: demonstration, experiment, discussion				
	Phase 1				
	Repeat last meeting activity: He connected one dynamo to another dynamo and then rotated it. He rotated first dynamo for ten times and asked student to count the second dynamo rotation. Second dynamo rotated 8 times only.	What kind of energy occur in rotation process? Why the rotation is different? Why the velocity of first dynamo affect the measurement of second dynamo?	Student in group G, H: Hypothesized that some energy was transferred to the heat energy. Student in group K, L: Hypothesized that electron movements affect the velocity of dynamo	Science, Mathematics, Technology	Logical mathematical
	Conduct experiment to prove the hypothesis		Student in Group G & H: Experiment: Put the wire of dynome into water in baker glass, they count the change of water temperature		

Table 4.6: Continued

Date	Activity	Teacher question	Student Response	STEM Integration	Trained Intelligence
12-06-2013		What is definition of Watt (power) ?	Student in group K and L, conduct a study litelarure through textbooks, they assume that energy is needed in the electron movement. If the dynamo velocity increase, the time for electron movement is shorter, thus it need more power.		
	Phase 3				
	Discussion Teacher demonstrate the movement of single dynamo connected to the wire	What is energy mechanic? How to count it? What energy occur in diggestion system?	Em = Ep + Ek $Ek = 1/2\ mv^2$		
17-06-2013	Topic: : Momentum Duration: 1 hours **Goals:** To understand momentum **Method**: demonstration, experiment, discussion				
	Phase 1				
	Demonstrate a phenomena of two balls, both of them were fallen on the table, but they bounched in different height	Why was it happen?	Planning the experiment	Science and Mathematic	Logical mathe matical
	Phase 2				
			- some students measure the mass)group L) - some student measure the velocity (group J) - some students try to throw it on the sponse (group D) - some student only discuss in a group (group C)	Science and Mathematics	Logical mathematica l Visual spatial Body kinesthetic

Table 4.6: Continued

Date	Activity	Teacher question	Student Response	STEM Integration	Trained Intelligence
	Phase 3				
	Teacher show ruler in different length. The rulers was bended. Longer ruler easier to be bent than the shorter.	Why shorter ruler is harder to be bent than the longer?	 students measure the ball mass when it bounched to the sky and after landed. They found the different mass.		
28-06-2013	Discuss about what was studied last meeting about two different ball that has different reaction	What was make the ball have different reaction?	- it has relation to energy concept  Hard ball can bounch, soft ball cannot bounce	Science	Logical Mathematical Visual spatial Body Kinesthetic
	Phase 2				
	Exploration		Conduct a momentum process of two balls by colided it, and observe what collision would be happen.	Science	Logical Mathematical Visual spatial Body Kinesthetic
	Phase 3				
	Discussion	Teacher ask student to present their result Make a report	Present the result Some showed that hard ball was bounched farrer than soft ball Soft ball have inertia energi bigger than hard ball so that it can not bounched as far as the hard ball	Science	Verbal linguistic Logical mathematical

Overall, the teacher conducted learning process through the scientific approach and the inquiry methods. He thought science as a single disciplinary to the students and correlated to mathematics as tools and technology as an application of the science concept. From this fact, null hypothesis 3.b was accepted. It was concluded that there were no various STEM integrations in learning process.

Furthermore, teacher gave freedom to the student to get their knowledge, and then students showed different ideas in every lesson based on their prior knowledge. Teacher asked students to think of demonstrated phenomena, posed an inquiry question "why" in order to trigger students' logical thinking and problem solving. Moreover, teacher let students conduct experiments based on their ideas to prove their hypothesis. In most lessons, students were trained to develop their logical mathematical and verbal linguist in solving the problem. They were trigger to think logically in finding the answer by gathering information from many sources. This was supported by the average "gain" score data of multiple intelligences that showed in figure 4.4. The diagram described that students estimated their logical mathematical higher in one semester. It is higher than three other intelligences (EI, NI, and SI) and lower than VL and MR. It was not surprising for LM estimation result was increased, but it raised question why their musical intelligences estimation was also increased.

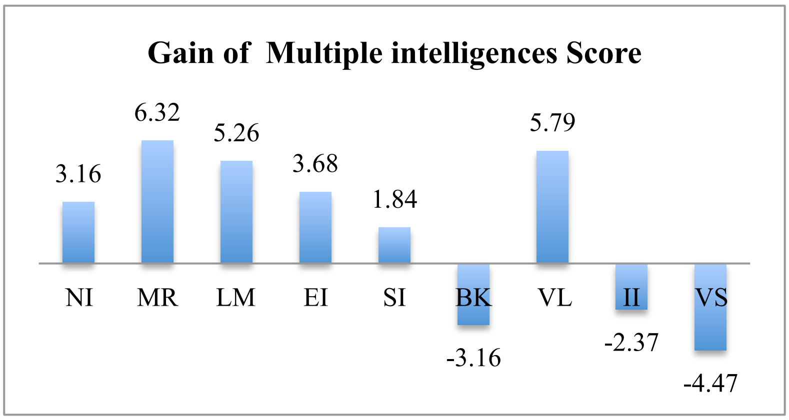


Figure 4.4: Average Score Gain of MI Profile

It can't be neglected that there were external factor that influence students' estimation on their multiple intelligences. One of consideration is they not only got science lessons but also other lessons in one semester. Inadvertently, most of

these students were dominant in musical intelligence; therefore they were also estimate musical intelligence higher than others at the end of semester. The student's multiple intelligences profile is shown in figure 4.5.

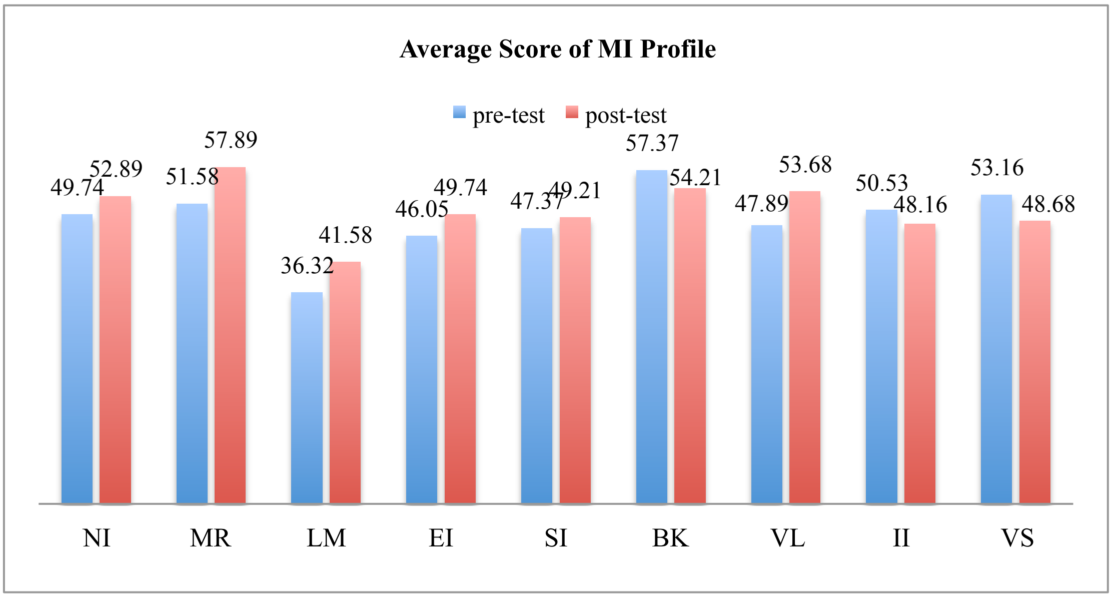


Figure 4.5: Average Score of MI Profile

The impact of learning process to the average score of multiple intelligences was analyzed statistically using t-test, to be able to count the differences of the average score in one semester. The result (table 4.7) showed that t observed values in all areas of intelligence were exceeding the t critical value, and then the null hypothesis 3a was rejected at 0.01 level. It found that there was a significant difference of multiple intelligences profile in one semester.

Table 4.7: Result of the t-test

Area of Intelligences	NI	MR	LM	EI	SI	BK	VL	II	VS
Pre-test	49.74	51.58	36.32	46.05	47.37	57.37	47.89	50.53	53.16
Post-test	52.89	57.89	41.58	49.74	49.21	54.21	53.68	48.16	48.68
$\mathbf{t}_{\text{observed}}$	3.74	5.00	4.43	4.44	4.31	5.51	4.02	4.12	4.83
$\mathbf{t}_{\text{critical}}$	2.438	2.438	2.438	2.438	2.438	2.438	2.438	2.438	2.438

IMPLEMENTATION OF STEM EDUCATION STUDY IN JAPAN AND INDONESIA

Term of STEM has been known since 1990 introduced by NSF when they conducted program related to science, technology, engineering and mathematics. Refer to this term, educator have different perspective on it. Beyond this diversity, the implementation needed an improvement. These have been doing since 2010 in the U.S to increase advanced training and careers in STEM fields, to expand the STEM-capable workforce, and to increase scientific literacy among the general public (NRC, 2011).

Affected by this issue, Japan and Indonesia was triggered to enhance STEM education in order to achieve similar capability of human resources. STEM education was invited to achieve goals in Indonesian 2013 national curriculum, while it was responded to MEXT's policy that wants to improve science and technology education in Japan.

Different methods of implementation were taken in the context of Indonesia and Japan. It was regarded as the content standard of curriculum and issues in each country. Refer to the previous studies of multiple intelligences; the implementation was taking places without ignoring the diversity of student's intelligence in solving the problems, it considered to a different ways of getting knowledge. Results of the studies were presented in order to show evidences of improved attitudes toward STEM and increased STEM knowledge and skills.

Challenges in First STEM Education Implementation in Japan: Analysis of Students' Knowledge through Mind Mapping and Students' Multiple Intelligences Characteristic

The first implementation of STEM education in Japan was defined as trans-disciplinary approach to the major issue that applies in STEM summer camp program that took an issue of *tsunami*. This issue was taken in order to awake students' awareness of hazard probability that would be happen in the near future that reflect from tragedy on 11 March 2011 at 02.46 PM. On that time, Japan was struck by a magnitude 9.0 earthquakes, with the epicenter 130 kilometers from its northeast Pacific coast. The earthquake generated a devastating tsunami with huge waves estimated to have reached more than 38 meters. The consequences of the earthquake and tsunami in terms of deaths, injuries, economics and environmental

damage were enormous. Moreover, Shizuoka is a prefecture that close to the seashore that was assumed by Katsuhiko Ishibashi (1976: Shizuoka Prefecture, 2010) will have the large-scale earthquake occurred in the Tokai area centering around Shizuoka Prefecture in the future. Thus, students were asked to design a solution of this issue.

This program was emphasized on exploring student's knowledge of tsunami and students' characteristic of MI and identifying the processes of implementation that focusing in engineering activities. We introduced Define-Develop solution-Optimize an iterative cycle of design that promote in NGSS (2013), and identified students creativities by analyzing what kinds of solution ideas that made by students to solve tsunami issues after we gave them engineering activities.

Furthermore, we invited mind map method to collect students' knowledge. Mind Map was a graphical representation used to generate new ideas from a main topic. Tony Buzan developed it around 1974 when he published his popular book "Use Your Head". Thoughts were often difficult to express in a linear order. Ideas initially come to mind without a logical structure. Mind Mapping allows ideas to be represented non- linearly, using keywords, sentences and pictures in a graphical form. The elements were connected to short descriptions by lines and arrows. This flexibility helps in eliciting new ideas and was ideal for creative brainstorming (Alexandra Okada, 2005).

On the other hand, Gardner (1989) viewed that children had unique and diverse abilities, and it was meshed well with educator initiative that children learn in different way. He defined intelligences as bio-psychological potential that could be influenced by experience, culture, and motivational factors. Previous MI research was focuses on the profile (Furniham, J& Fukumoto, S. 2008、Gazel, H. 2010、Al Jadiry, R. 2012) and they impacted on the students, for instance, a majority of Project SUMIT schools reported improved standardized test scores, reduced disciplinary infractions, increased parent involvement, and increased ability to work with other students who had learning disabilities (NIUSI, 2004). Perhaps most compelling among the positive outcomes was that teachers and administrators realized the power of MI for all students, including those students with learning differences. In solving problems, *all intelligence is needed to work together, the greater the number of outlets one can find for expression, the more likely is one to find creative approaches to problem situations* (Gardner, 1999). However, individuals have one or two superior intelligences profile (Suwarma &

Kumano, 2013) that becomes their characteristics in solving problem and attain knowledge, which can influence their learning styles.

Aim of this study was to analyze the increase of STEM knowledge through *tsunami* issues, observe multiple intelligences profile and its characteristic, and assessed creativity skill in generating idea of solution. Furthermore, challenges of this implementation were discussed based on the analyses result.

Research Methodology:

Students grouped based on their dominant multiple intelligences. They were asked to fill MI Quiz that adapted from Laura Candler (Teaching Resources at http://home.att.net/~teaching, 2011) (see Appendix B.2a-2b). This questionnaire consists of 21 statements that measure seven intelligences areas. The score for each section was calculated and multiplied by 10. If a student's score was between 0-25, it was categorized as "not advanced". Scores of 26-50 were classified as "advanced". Those of 51-75 were classified as "intermediate advanced" and those of 75-100 as "very advanced". Twenty-nine fifth and six grades elementary students joined the camp. They were from some schools in *Fujieda* and *Shizuoka Shi*. They were recruited from two other related activites; *Rikadaisuki* (We like science very much) Program that conducted every year since 2011; and Fujieda STEM (Waku-waku) Program that just started this year. STEM summer camp activity conducted in two days on 27-28 August 2013 at Yaizu. The implementation method is shown in figure.1. Students' MI characteristic, knowledge and design solution data collected during STEM activities in first and second day.

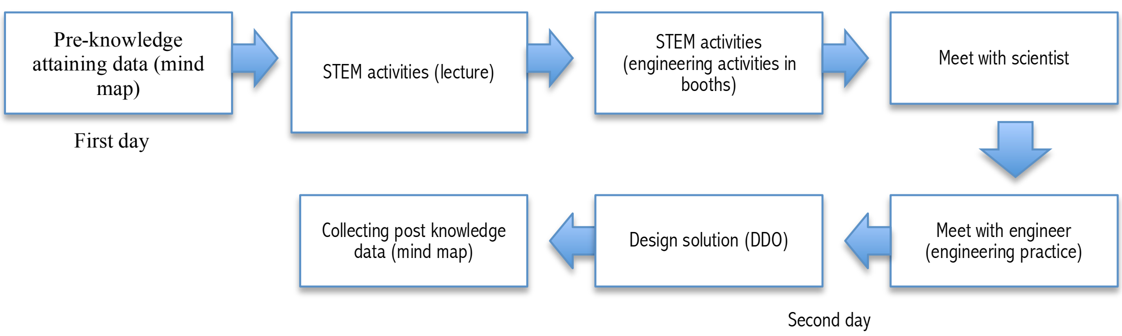


Figure 4.6: Activity Framework of STEM Camp 2013

Null hypothesis:

a. There is no significant difference of STEM knowledge in *tsunami* issues before and after summer camp activity.

b. There is no significant difference of creativity between group of dominated intelligences

c. There is no correlation between dominant intelligences and observed characteristic.

Research Question:

a. What is the impact of STEM camp activity to students understanding of STEM knowledge in tsunami issues?

b. What is the impact of both activities and dominant intelligences profile to student's creativity in generating the ideas?

c. Did student's characteristic show positive relation to their dominant multiple intelligences profile?

d. What was the challenges face in this STEM implementation?

Result

A. Students' STEM Knowledge and Creativity

STEM knowledge was defined as students' knowledge related to STEM disciplines that reflected from their ideas in solving *tsunami* problem. They wrote the ideas on a mind mapping system that discussed in-group with the same dominant multiple intelligences. Mind mapping was developed as an effective method to generating ideas by association. The ideas were scored by logic-not logic; relevant-not relevant to the issue; and categories in which area the ideas connect to S, T, E, or M. If the idea is logic or relevant, then it is scored '1', but if not-logic or not relevant, it is scored '0'. The rubric were adapted from Cronin P.J (1982) rubric that considering the grouping ideas.

Creativity was defined as students' creative thinking in generating solution ideas of tsunami issues. The creativity was scored based on the rubric that adapted from NRC, 2010 that considering several criteria; fluency, flexibility, originality, and abstractness. The fluency refer to the simplicity of idea, flexibility refer to rigid/not-rigid idea related to the concept of tsunami, originality refer to common or uncommon ideas among the groups, and abstractness refer to logic or not- logic idea.

The detailed rubric was presented in appendix C, and the detailed students ideas served in appendix E. The results of ideas analysis at students' mind map are presented in table 4.8.

The impact camp activities to students' knowledge was seen from the differences score before and after camp activities, and the impact of dominant intelligence to students' creativity was analyzed from variance analyses between groups. The creativity ANOVA results were presented in table 4.9

The increases of student's knowledge were analyzed from percent of logic and not-logic ideas, relevant and not-relevant ideas, and STEM related number before and after camp activities. Almost all group showed that there was increase of logic ideas except the C group students who decrease -0.38 % lower than before camp activities. The A Group students had 50% logic ideas and 45.45% relevant ideas before camp activities and after camp activities, the logic ideas increase became 58.97% and the relevant ideas became 69.23%. They also presented 17 (39-22) more ideas after camp activities. The A group students are dominant in logical mathematical and visual spatial intelligence. The highest logic ideas differences can be seen at the D group students who dominate in naturalist intelligences; they not only get highest logic differences but also in number of ideas, and science related ideas.

Table 4.8: Creativity and STEM Knowledge Analysis Results

Group	Test	Analysis	No. idea	Creativity	Logic	Not-logic	Relevant	Not-relevant	S	T	E	M	Grouping	Total knowledge
A (LM + VS)	Pre-test	Sum Mean %	22	131 5.95	11 0.5 50.00	11 0.5 50.00	10 0.45 45.45	12 0.54 54.55	7	6	8	0	12	77
	Post-test	Sum Mean %	39	236 6.05	23 0.59 58.97	16 0.41 41.03	27 0.69 69.23	12 0.31 30.80	28	3	7	0	18	134
		d	**17**	**0.097**	**8.97**		**23.78**		**21**	**3**	**-1**	**0**	**6**	**57**
	t-test	**t_{ov}**			**0.914**									
B (LM + BK)	Pre-test	Sum Mean %	47	261 5.49	31 0.53 53.19	16 0.47 46.81	21 0.45 44.68	26 0.55 55.32	12	8	9	6	11	129
	Post-test	Sum Mean %	62	358 6.03	37 0.60 59.68	25 0.40 40.32	30 0.48 48.39	32 0.52 51.61	22	2	13	1	11	162
		d	**15**	**0.543**	**6.49**		**3.71**		**10**	**-6**	**4**	**-5**	**0**	**33**
	t-test	**t_{ov}**			**0.363**									

Table 4.8: Continued

Group	Test	Analysis	No. idea	Creativity	Logic	Not-logic	Relevant	Not-relevant	S	T	E	M	Grouping	Total knowledge
C (MR)	Pre-test	Sum Mean %	47	251 5.46	34 0.74 73.91	10 0.22 21.74	30 0.65 65.22	14 0.30 30.43	13	6	16	2	12	125
	Post-test	Sum Mean %	69	406 5.97	50 0.74 73.53	18 0.26 26.47	34 0.49 49.28	34 0.49 49.28	25	6	4	1	20	194
		d	**22**	**0.514**	**-0.38**		**4.73**		**12**	**0**	**-12**	**-1**	**8**	**69**
	t-test	**t**			**0.282**									
D (NI)	Pre-test	Sum Mean %	28	142 5.07	16 0.57 57.14	12 0.43 42.86	25 0.89 89.29	3 0.11 10.71	5	16	3	4	6	84
	Post-test	Sum Mean %	54	320 5.93	40 0.74 74.07	16 0.30 29.63	48 0.89 88.89	8 0.15 14.81	36	17	0	1	17	183
		d	**26**	**0.854**	**16.93**		**-13.2**		**31**	**1**	**-3**	**-4**	**11**	**99**
	t-test	**t**			**0.798**									
E (SI)	Pre-test	Sum Mean %	40	224 5.60	31 0.78 77.50	9 0.23 22.50	39 0.98 97.50	1 0.03 2.50	29	7	2	1	21	143
	Post-test	Sum Mean %	42	241 5.74	33 0.79 78.57	9 0.21 20.93	39 0.91 90.70	3 0.07 6.98	26	8	7	1	0	126
		d	**2**	**0.138**	**1.07**		**-1.57**		**-3**	**1**	**5**	**0**	**-21**	**-17**
	t-test	**t**			**0.198**									

Note : t_{cv} = 1.671 at α = 0.01

Numbers of ideas showed students' fluency in generating ideas, the group who were produced most ideas after camp activities was C group who dominated in musical rhythmic intelligences, generated 69 ideas, which almost 73% of them were logic, but 49.28% of them were not relevant to the issues. The lowest differences numbers of ideas can be seen at the E group students who dominated in social intrapersonal intelligence. They add two ideas only, but they produced 40 ideas in pre-mind map and almost 78% of them were logic and 90% were relevant to the issues, even though it was decrease -1.57% than before but they ideas were much more relevant than other groups.

Furthermore, most of students' ideas were more related to science (S) than technology (T), engineering (E) and mathematics (M). The D group generated 17 technology related ideas. It was higher than other groups even though they got the low differences score than others. Most of them produce engineering related ideas in post-test than technology.

The differences of students' knowledge were tested using t-test for independent sample with t critical value = 1.671 at 0.01 level of significance. The t-test result showed in table 4.8. It could be a consideration to accept the hypothesis (a), because there were not significant differences in students' knowledge before and after camp activities. Moreover, the differences of students' total and STEM knowledge among group were tested using Mann-Whitney U-test. The results showed that $U_{observed}$ value were lower than $U_{critical}$ value (Total knowledge: $U_{ob} = 2.5 < U_{cv} = 3.0$, STEM knowledge: $U_{ob} = 1.5 < U_{cv} = 3.0$).

Table 4.9: ANOVA Result of the Creativity

Creativity		Sum of square	df	Average of Square	F	F_{cv}
Pre-test	Between	11.37	4	3.790	0.631	2,37
	Within	1081.58	180	6.009		
	Total		184			
Post-test	Between	2.763	4	0.921	-0.44	2,37
	Within	-543.39	262	-2.074		
	Total		266			

Based on the creativity data, the D group students who were dominated in naturalist intelligence achieved the highest differences score. These facts were coherent to percentages number of logic and relevant ideas that were produced ($d_{creativity} = 0.854$, % of logic ideas = 74.07%, and % of relevant ideas = 88.89%). Unfortunately, the impact of dominated intelligences to the creativity cannot be identified statistically. The ANOVA result (Tabel 4.9) showed that there is no significant different of creativity between groups of dominated intelligences (Fob < Fcv). Thus, the null hypothesis (b) should be accepted.

On the other way, the impact of booth activities and dominated intelligence were analyzed from students ideas related to the booth activities, whether or not the ideas came from booth activities, that indicated by the same concept in booth activities and the ideas. For instance, the D students who had ideas to make 'floatation ring' that having same key word with booth activities of 'water craft' that asked students to design a simple boat from a piece of aluminum foil that could hold many coins to float on water. From this activity, students generate their ideas by imaging a floatation ring that can relocate many refugees. The booth activities consisted of nine themes: chair, watercraft, roller coaster, suisin-kutsu, pumpkin launcher, paper bridge, diapers, solar cooking, and otolith. The result

showed that some of students' ideas were come from booth activities ideas. In general, the D group students who were dominated in naturalist intelligence got the highest number of related words. The complete relation analyses are presented in table 4.10.

Table 4.10: Idea Analysis to Booth Activity Theme

Group	Number of related ideas to booth activity	Theme
A	8	Pumpkin launcher Roller coaster Robot
B	8	Diapers, Watercraft Robot
C	5	Otolith Diapers
D	9	Suisin-kutsu Diapers Watercraft Pumpkin Launcher
E	4	Diapers

B. Student's MI Profile and Those Characteristics

1. Student's Multiple Intelligences Profile

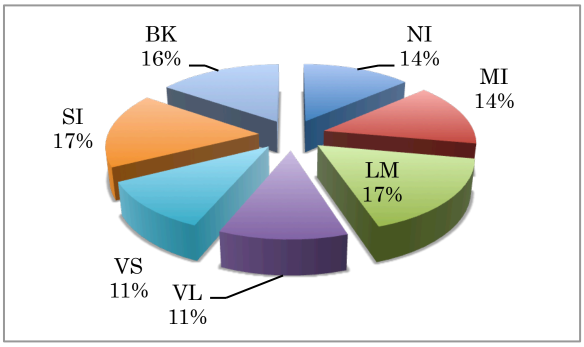


Figure 4.7: Diagram of Student's MI Profile

The diagram in figure 4.7 showed students' MI profile, which was taken from MI questionnaire "How Many Intelligences Are You Dominant". Most of students (17 %) were dominant in logical mathematical and social interpersonal intelligence; some students (14%) were in naturalist intelligence and musical intelligence; and few students (11%) were in visual spatial and verbal linguistic intelligence.

The diagram described that most of students not only dominate in logical mathematical and social interpersonal intelligence but also in body kinesthetic intelligences (16%). These profiles were consistence with other science students' profiles that were dominant in logical mathematical and body kinesthetic because science train them to be logic and energetic in conducting experiments (Suwarma & Kumano, 2013).

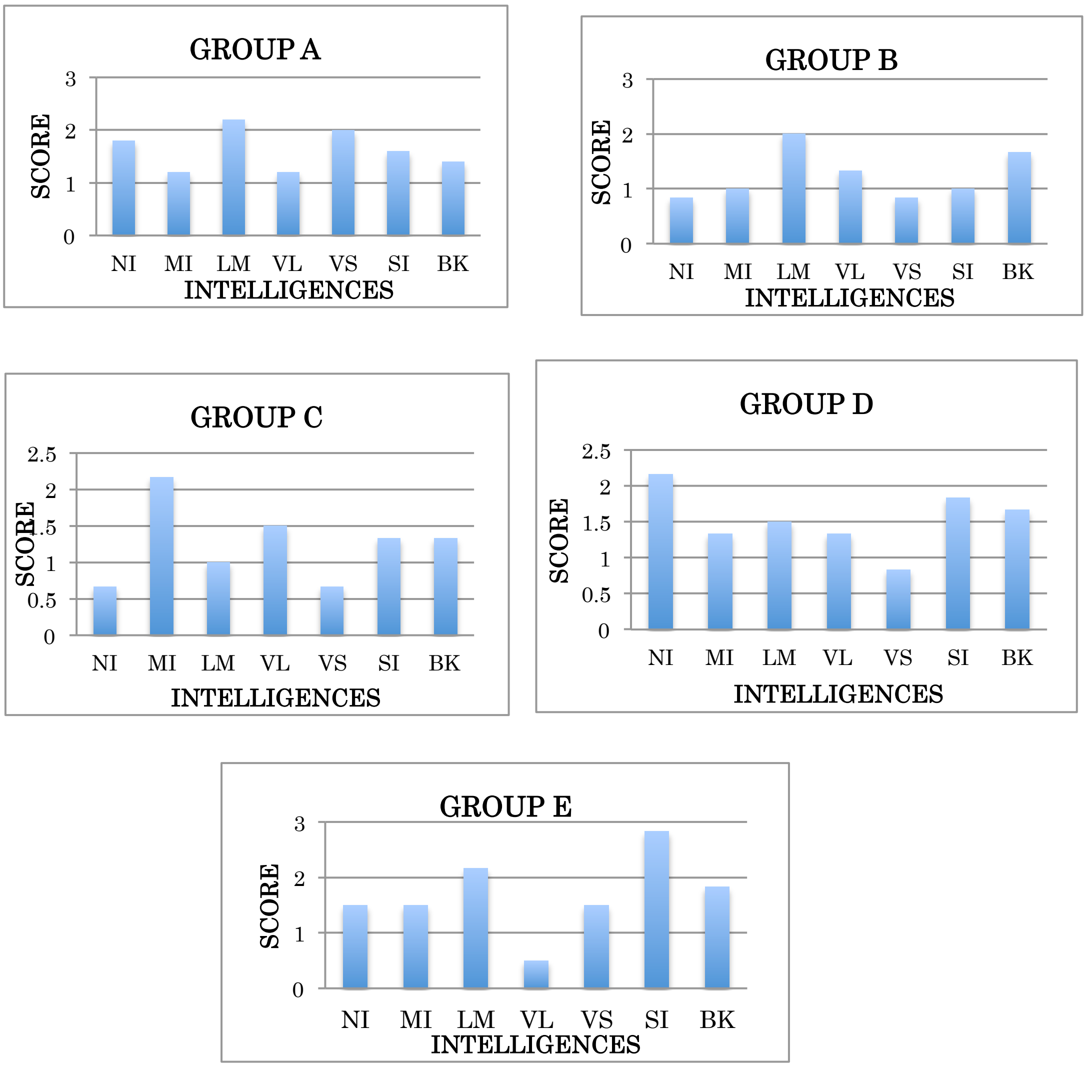


Figure 4.8: Graph of Grouped Student's Dominant Multiple Intelligences Profile

Students were divided into 5 groups (A, B, C, D, and E) based on their dominant intelligence. They were analyzed based on strong statements criteria for each intelligences area. Each intelligence area at least had one strong statement. If students had more than two dominate intelligence, it would be decided whether or

not they choose those statements. Group A were students who dominated in logical mathematical and visual spatial intelligence, group B were in logical mathematical intelligence, group C were in musical intelligence, group D were in naturalist intelligence, and group E were in logical mathematical and social interpersonal intelligence. Their profiles were shown in the figure 4.8.

2. Analyzing MI Characteristics

a. Group A (logical mathematical and visual spatial)

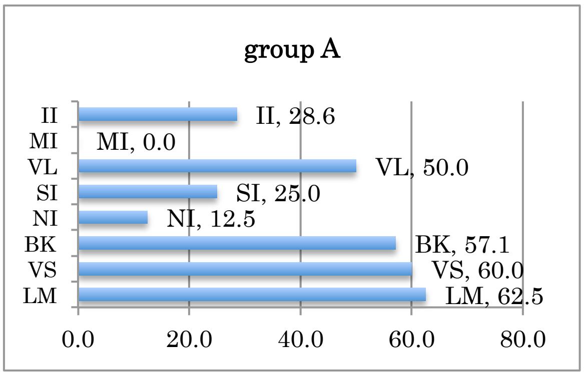


Figure 4.9: MI Characteristic of Group A

Group A consisted of 3 male and 2 female students. From the observation, most their characteristic were consistence to logical mathematical intelligence characteristic (62, 5%) and visual spatial intelligence (60%). This group had not match characteristic that showed their character in musical intelligence (0%). Their observed characteristic were analytical, uses logic, uses number, good at problem solving, enjoying experiments, thinks in 3D, great imagination and having excellent hand to eye relationship.

b. Group B (logical mathematical intelligence)

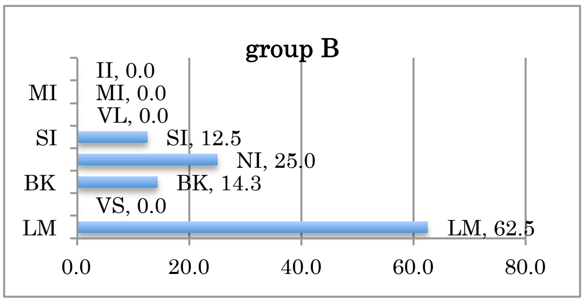


Figure 4.10 MI Characteristic of Group B

Group B consisted of 4 male and 2 female students. They had dominant characteristic that suitable to logical mathematical characteristics (62%), naturalist intelligence (25%), and social interpersonal intelligence (13%). Characteristic of body kinesthetic, music and intrapersonal intelligence (0%) cannot be detected for this group. Their observed characteristic were analytical, using logic, good at problem solving, enjoying scientific experiment, able to think about abstract concepts, classifying or sorting things,

looking for and recognizing pattern, working well with others, and seeing situations from different perspectives.

c. Group C (musical intelligences)

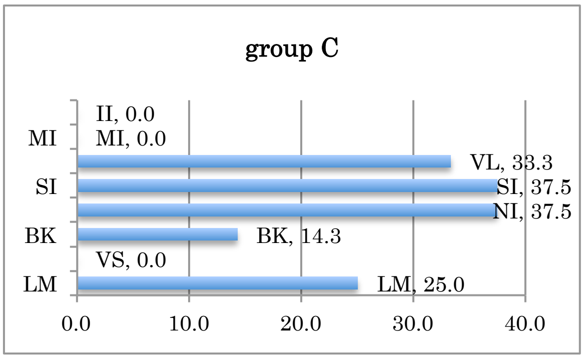


Figure 4.11: MI Characteristic of Group

This group consisted of 3 male and 3 female students. They were good at problem solving, enjoying scientific experiments, connecting to nature (it was observed from picture that they had made), good at categorizing and cataloging information easily (it was observed from concept map arrangement), good at sensing other feelings, good at communicating verbally, good at resolving problem in group. Based on observation sheet, they had dominant characteristic in social interpersonal and naturalist intelligence (37.5%). Musical intelligence characteristic cannot be observed for this group because there were no activities to support this intelligence.

d. Group D (naturalist intelligence)

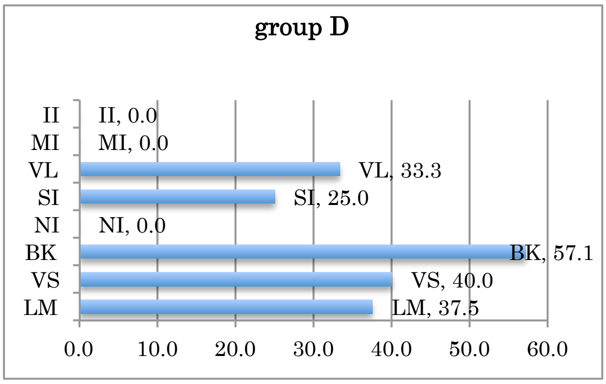


Figure 4.12: MI Characteristic of Group D

This group consisted of 5 female and 1 male students. They were student who had dominant naturalist intelligence, but in fact, they didn't have these characteristics (NI: 0%). Otherwise, they used logic, were good at problem solving, enjoying scientific experiment, had great imagination, excellent hand to eye relationship, enjoying creating thing with their hands, tended to remember by doing than hearing or sensing, participated actively in every activity, working well with other, good at communicating verbally, and good at debating or giving persuasive speeches.

e. Group E (logical mathematical and social interpersonal intelligence)

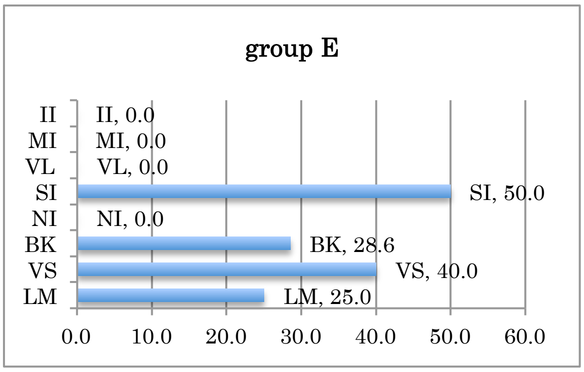


Figure 4.13: MI Characteristic of Group E

4 male and 2 female students in this group were good at reasoning skill, seeing and recognizing pattern, had excellent hand to eye relationship, enjoying creating things with their hands, had excellent physical coordination, working well with others, good at communicating verbally, good at resolving conflict in groups and creating positive relationship with others. They showed dominant characteristics in social interpersonal (50%) and visual spatial (40%), while 25% characteristic of logical mathematical observed from their behavior. These results were surprising for them who had dominant logical mathematical intelligence. In fact, they showed good body kinesthetic characteristic (28, 6%). Musical and naturalist intelligence characteristic cannot be observed in this group. It needs further analysis in forms of instrument.

The consistencies of multiple intelligences self-estimate profile and the observed MI characteristic were analyzed from the correlation analyses of MI profiles and characteristics percentage. *R*-value of Pearson Product Moment correlation results showed that the A group students showed the highest consistencies (r_A = 0.708) than other groups. On the other hand, the other R-value of B, C, D, and E group students showed lower consistencies (r_B = 0.457, r_C = 0.405, r_D = 0.476, and r_E = 0.4).

C. Challenges in STEM Implementation

1. The Challenges in Implementing Technology and Engineering

The challenges were analyzed from seven element of implementation evaluation; Integration of Science and Math, technology, engineering design, STEM professionals, link to career, what students are doing, and autonomy. Three STEM researchers evaluated it, and the result was concluded in table 4.11.

Table 4.11: Evaluation Result of STEM Implementation in Camp Activities

No	Elements	Categories
1	Integration of Science and math	Emerging
2	Technology	Emerging
3	Engineering design	Emerging
4	STEM professional	Implementing
5	Link to career	Emerging
6	What students do	Exemplary
7	Autonomy	Implementing

2. Using STEM Context

Applying STEM related issues into the STEM program is the most significant challenges in the implementation processes. Addressing this challenge requires an educational approach that first place life situation and global issues in a central position. The uses the four disciplines of STEM are to understand and address the problem. The evaluation were included some domains in three step of implementation purposes, program, and practices by evaluating the time needed, participant, location, product, problem, and agreement. This evaluation strategy was developed based on Bybee (2013) suggestion of 4Ps, but we develop into 3Ps. The results are shown in table 4.19.

Table 4.12: Evaluation result of 3Ps (Purpose, Program, and Practice)

Dimension	Time	Participant	Location	Product	Problem	Agreement
Purposes						
Establishing goals for STEM Activities	It need more than one week	Fairly engage faculty collogues	Easy to be accessed (at university)	Goals related to STEM purposes	How to create a program that take less risk for students	Fair
Establishing priorities for STEM goals in the STEM activities	It took more than one week	Fairly engage faculty collogues	Easy to be accessed (at university)	Fairly imply the first purposes of STEM education	It took more less cost to the program conductor The participant took fair responsibility	Fair
Providing justification for STEM education	It took more than one year	Actively engage faculty collogues and relevant community	Easy to be accessed (at university)	It seldom produce STEM education evaluation instrument	it gave not much (fair) benefit to the students, and participant also didn’t took much responsibility	Fair

Table 4.12: Continued

Program						
Developing material or adopting a program for STEM	It took more than one month	Engage faculty collogues	Easy to be accessed (at university)	Problem based learning instruction that fair related to civic phenomena	It took fair cost to the program conductor	Fair
Implementing the STEM program	It took less than one month	29 elementary and secondary students	Easy to be accessed (at youth building Yaizu)	Generate solution ideas that related to civic phenomena (tsunami)	It took fair risk to the student The participant took much responsibility	Good
Practice (during 2013 STEM Camp)						
Changing teaching strategies for STEM	It took more than 4 month	Actively engage faculty collogues and relevant community	Easy to be accessed (at university)	Better teaching strategies scenario in STEM	It took more cost to the program conductor	Fair
Dimension	Time	Participant	Location	Product	Problem	Agreement
Adapting materials to unique needs of teacher, schools, and students	It took more than 4 month	Actively engage faculty collogues and relevant community	Easy to be accessed (at university)	Produce simple material that needed by students	It took more cost to the program conductor	Fair

<u>Challenges in Second STEM Education Implementation in Japan: Analysis of Students' Knowledge through Concept Mapping, Students' Multiple Intelligences Characteristic, and Creativity Skill</u>

Analyzing the results study of STEM education implementation in 2013, the second implementation in 2014 was redesigned to achieve better results based on the goals. Similar to the first implementation, the aim of this study was to analyze the increase of STEM knowledge through *natural hazard disaster* issue, to observe multiple intelligences profile and those characteristics, and to assess creativity skills in designing the solution. Furthermore, challenges of this implementation were discussed based on the analyses of those results.

Students were given a problem based learning (PBL) to design a sustainable environment in their hometown to prevent hazard disaster in their future. They were asked to create a prototype/miniature of their own design. They were putting into groups based on possible hazard disaster in their hometowns using their dominant intelligences profile in order to provide convenient team works when they were communicating their ideas. Project based learning were chosen as the method for students in completing their tasks, using iterative cycle of design D-D-O approach (Fig. 4.14) that adapted from NGSS (2013).

To guide students on completing their task, they were provided some booth activities that related to each hazard disaster topic. The booth activities were given in the first day after they got lecture of "disaster in the earth" from the professional in earth science field. The booth activities were related to theme of volcano, tsunami, fire and nuclear radiation. In the second day, students continue their team works in discussing their design that should be presented in the same day. The detail activities were provided in appendix E.

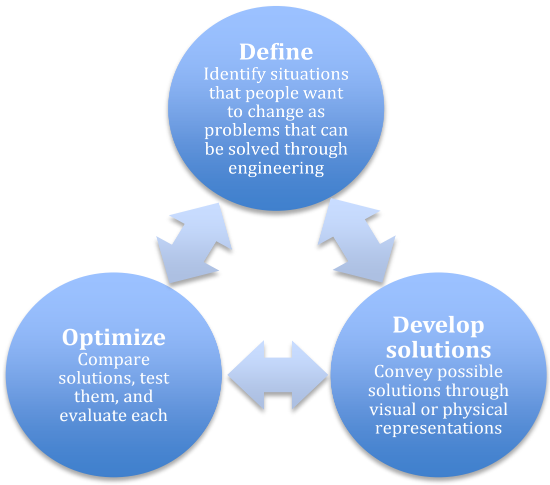


Figure 4.14: Iterative cycle of design diagram source: NGSS, 2013

Methodology:

The STEM summer camp was conducted in Yaizu on 27-28 September 2014. It was participated by twenty-one Japanese students of fifth to sixth grade of elementary school and first to second grade of middle school. Moreover, five Indonesian students who were chosen based on their STEM project results joined the camp to get new experience in STEM education implementation. Japanese

students came from Fujieda, Hamamatsu and Shizuoka-shi. They were divided into four group based on their dominant and hazard possibilities in their hometown. The students were asked to fill MI quiz, creativity skill, and STEM Education Implementation questionnaire that divide into three domain; STEM interests, STEM careers and STEM integration perceptions (see appendix E.3), and to create concept map of natural hazard disaster at the beginning and at the end of the camp activities. Making concept map activity was initiated by puzzle game activity where students were asked to find the twenty-one words in puzzle. The words wrote in *post-it* paper twice, for concept map in the first day and another one for the second day. The results were analyzed based on concept map rubric that adapted from Novak. J. D & Gowin, D. B (1984), and Cronin, P.J (1982). During STEM camp activities, students' characteristic of multiple intelligences were observed refer to observation sheet which adapted from Connie Hine (2008) (see appendix. B.3c). The observers were asked to write a checklist in every criteria of multiple intelligences, the percentage (%) of total characteristics criteria in each intelligences area were calculated and then compare to the percentage (%) self-estimate of multiple intelligences. Furthermore to see the impact of STEM activity to students' creativity skill, the solution designs were scored based on creativity rubric (see appendix C.2.1).

<u>Null Hypothesis:</u>

a. There is no significant difference of STEM knowledge in *natural hazard disaster* issues before and after summer camp activities.

b. There is no significant difference of student's attitude toward STEM interest, STEM agreement and STEM perception.

c. There is no correlation between dominant intelligences and observed characteristic.

d. There is no significant difference of MI self-estimate score before and after camp activity.

e. There is no significant increase of creativity skills before and after camp activities.

Research Question:

a. What is the impact of STEM camp activity to students understanding of STEM knowledge in *natural hazard disaster* issues?

b. What is the impact of STEM camp activities to student's attitude toward STEM interest, STEM career and STEM integration perception?

c. Did student's characteristic show positive relation to their dominant multiple intelligences profile?

d. What is the impact of STEM activity to students' MI self-estimate score?

e. What is the impact of STEM camp activities and dominant multiple intelligences profile to student's creativity in design the solution?

f. What is the challenges face in this STEM implementation?

Result

A. Student's Group Based on Multiple Intelligences Profile

There were two kind grouping systems: Japanese students were grouped based on their dominant intelligences, while Indonesian students were group separately. Students were asked to estimate their intelligences profile by giving score that is from one to five for each statement in each intelligences area. The scores was sum up and the percentage was calculated for each intelligences areas.

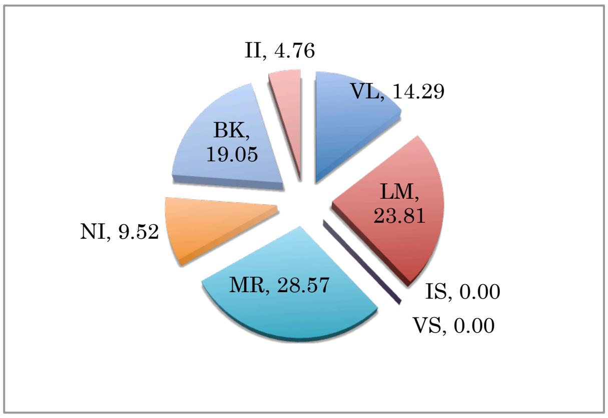


Figure 4.15: Percentage of Japanese Students' Dominant Intelligences

Figure 4.15 showed the percentage diagram of Japanese students' dominant intelligences, where students were mostly dominated in musical rhythmic intelligences (28.57%), and less dominate in intrapersonal (4.76%), interpersonal social (0%) and visual spatial intelligences (0%). The other developed dominated intelligences were logical

mathematical (23.81%), body kinesthetic (19.05%), and verbal linguist (14.29%). Based on this fact, students were divided into four groups A, B, C, and D. The A group were dominated in musical rhythmic, B group in body kinesthetic, C group in logical mathematical, and D group in verbal linguist and intrapersonal intelligences. It was illustrated in figure 4.16.

It showed that the A group reach highest average score of musical rhythmic intelligences (33.50); the B group reach highest average score of body kinesthetic (36.25). Moreover, the C group not only reached highest score in logical mathematical (33) but also in verbal linguist (31.34), social interpersonal (32.4), naturalist (32) and intrapersonal intelligences (31). This group had higher average score than other group. Finally the D group did not reach highest average score comparing to other group, however they were dominant in intrapersonal (30) and verbal linguist intelligences (29.6).

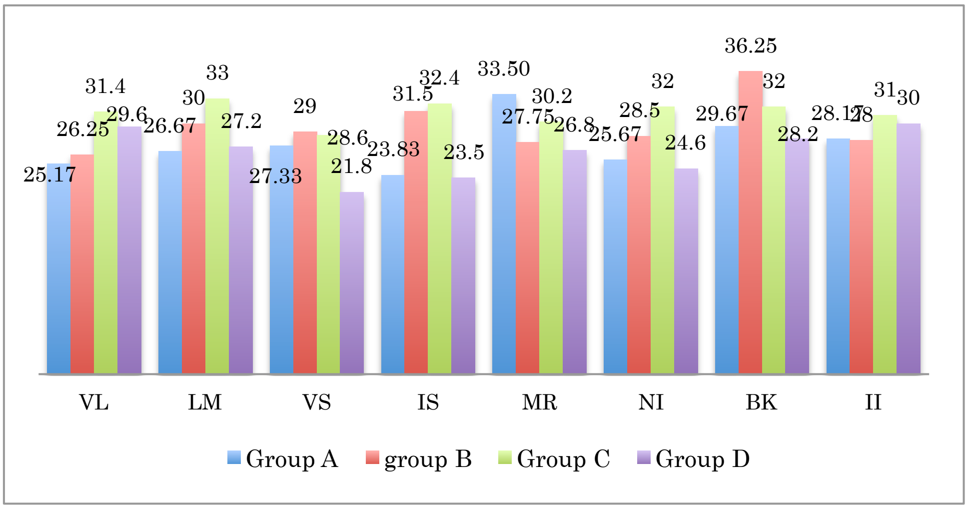


Figure 4.16: Graph of Dominant Intelligence in Group A, B, C, and D

B. The Impact of STEM activity to Students' Understanding of STEM Knowledge of Natural hazard Disaster

The processes of concept map activity was initiated by puzzle game activity that leads students to find the concept words that connected to natural hazard disaster issues. Students were provided twenty-one words that had to be found in the puzzle. The words were plate tectonic, earthquake, tsunami, eruption,

landslide, fire, nuclear power plant, liquefaction, land subsidence, lava, volcanic gas, volcanic ash, radiation, electricity, wildlife, plants, building, human, water pipe, run-up/overflow, and transportation. This strategy was developed to achieve better concept map results than last year camp.

Concept maps were tools for organizing knowledge (Novak, J. D., 1984). He defined concept as a perceived regularity in events or objects, or records of events, or object designed by label. Concept map in this research were developed to follow and understand changes in students' knowledge of natural hazard disaster and STEM knowledge. The concept maps were scored based on rubric that adapted from Novak J. D (1984) and Cronin P. J, 1982). It includes five domains of scoring namely proposition, hierarchy, cross-link, examples, and grouping. Novak suggested that there were two features of concept map that were important in facilitation of creative thinking, the hierarchical structure that was represented in good map, and the ability to search for and characterize cross-link. Thus, one proposition was scored in one (1), while one level concept at hierarchy was scored in five (5), and the valid and significant cross-link was scored in ten (10). In addition, for an event or object in the example domain was scored in one (1), however if the events or objects were described the students' understanding of STEM knowledge; it would be scored in five (5). Finally, in the grouping domain: one point gave to *general grouping* if it was a group of single sub concept that link without proposition; two point for *point grouping* if a number of single concepts emanating from one concept; three point for *open grouping* if there were three or more concepts linked in a single chain; and 4 point for *closed grouping* if there were concepts that form a closed system/loop (detail rubric see appendix C. 1.1). The impact of STEM camp activity to students' knowledge can be seen from results of analysis on pretest and posttest scores that were described in table 4.13.

The data showed differences score in each domain for every group. For instance, the C group students who were dominated in logical mathematical intelligences reached highest differences in proposition (30), cross-link (10), and grouping domain (74), but it had less difference in hierarchy (6) and example (1). The reason simply because of they did not add enough word of concept and example in their map. They also did not provide a proposition word in the pre-concept map, thus after adding the valid proposition in the post-concept map, their proposition score increased.

On the pre-concept map, the C group students put level 1 of concept in the

middle of map; it showed that they did not arrange it in a good hierarchy. They added a new word ‘secondary disaster’ to connect fire, tsunami, liquefaction, and eruption. It showed their understanding of the secondary disaster type that came after primary disaster. Even though they did not describe clearly what the primary disaster was, they put ‘plate tectonic’ as the main concept that connected to the ‘earthquake’ word; it showed their understanding of the cause of earthquake. They missed one example word ‘run-up/overflow’ that provided in puzzle game, and they added 7 new example words that showed their STEM knowledge understanding, thus they got score 14. They also did not group the concept, but they added 4 words related to solution that reflects their STEM knowledge understanding.

Table 4.13: Score of domains in students’ concept map

Group	Proposition			Hierarchy			Cross-link			Example			Grouping		
	Pre	Post	d	Pre	Post	d	Pre	Post	d	Pre	Post	d	Pre	Post	d
A (MR)	7	24	17	20	26	6	0	0	0	15	15	0	30	38	8
B (BK)	35	20	-15	19	22	3	0	0	0	13	25	12	68	96	28
C (LM)	0	30	30	14	20	6	0	10	10	14	15	1	0	74	74
D (II)	20	22	2	18	24	6	0	0	0	13	9	-4	62	61	-1

Group	STEM knowledge		
	Pre	Post	d
A (MR)	6	35	29
B (BK)	20	65	45
C (LM)	20	40	20
D (II)	5	50	45

Table 4.14: Score of natural hazard disaster and STEM knowledge understanding

Group	Natural hazard disaster knowledge understanding			STEM knowledge understanding of natural hazard disaster		
	Pre-	Post	d	Pre-	Post	d
A (MR)	72	103	31	6	35	29
B (BK)	135	163	28	20	65	45
C (LM)	29	152	123	20	40	20
D (II)	113	116	3	5	50	45
U_{ov}	3			0*		
U_{cv}	1			1		

* Significant at p = 0.025

Moreover, the C group students added 4 words related to STEM knowledge on the post-concept but it was lower than B group students (added 9 words), thus they did not get high difference score in STEM knowledge understanding. Their understandings of STEM knowledge were reflected from words: 1) diagonal brace

(to strength the building), 2) breaker system (in the building to stop the electricity automatically when the disaster come), 3) ground anchor (to prevent from landslide), 4) change the way to generate electricity, 5) create DAM, 6) break wall, and 7) floodgate (related to tsunami disaster without clear proposition word). In general (table 4.14), they reached highest difference score for the natural hazard disaster understanding. Furthermore, the STEM knowledge understanding from post-concept map described their understanding and concern more on fire disaster, they linked word 'fire' to 'building' and linked it to 'diagonal brace' and ' a seismic breaker'. This group experienced to learn 'fire' disaster in first session of booth activity. It showed the impact of booth activity to their STEM knowledge understanding.

The B group students who were dominated in body kinesthetic intelligences added 9 new word that reflect STEM knowledge understanding on post-concept map, thus they achieved high score differences. Their understanding of STEM knowledge about natural hazard disaster increased more than pre-concept map. It reflected from the words: went to higher place (they understand that when tsunami come, they had to go to higher place and consider how should they go there), levee, break wall, strengthen walls, strengthen polls, shelter, make evacuation place (students thought to build a strong structure to survive from disaster), evacuation drill (to reduce damage), saving energy, generating energy, making clean water from mud water (as a solution for energy damage during disaster), and learning STEM knowledge (as a solution in supporting their idea). Most of their solution ideas were related to tsunami disaster. This seems as an impact of their experience in first session of booth activity that gave more knowledge of tsunami to student.

The A group students who were dominated in musical rhythmic intelligences also increase their STEM knowledge understanding by adding six new words on the post concept map, better than pre-concept map that only have 3 words without clear proposition. The words on pre-concept map were; go to higher place (as a solution for tsunami), ground anchor (as a solution or landslide), emergency power supply (deal with electricity damage at house during disaster). The words on post-concept map were; predicting the way lava goes (to protect community from volcano eruption), making a structure that would not let the leak of radiation (in case of nuclear plant damage during disaster). This group was the only group that added the word related to volcano disaster in the post-concept that

was ‘predicting the way lava goes’. It was assumed because they got experience to learn more about lava pathway through the booth activities in the theme of volcano.

The D group who were dominated in intrapersonal intelligences and verbal linguist got the difference score the same as B group, but on pre-concept map they described only one word of STEM knowledge understanding, then they added 9 words on post-concept map. The word on pre-concept map is ‘break wall’ (to protect from tsunami disaster), and the words on post-concept map were: levee, evacuation building, map of hazard (deal with tsunami disaster), a systematic breaker (to stop electricity automatically when the disaster come), electric generation (as one function of nuclear plant), and they wrote other words related to electric generation such as: wind power, fire power, water power, biomass, solar light, snow ice heat application generation, geothermal heat. Moreover, they added idea of ‘make diagonal brace’, put electric generator in higher place, and think alternative way not to use natural gas in generating energy. From the post-concept map analysis, this group understood more on electric generation because in the first session of booth activities they got experience to learn more about nuclear radiation.

Since the samples number were independent and not fulfill the normal distribution criteria, the statistic analyses of students’ knowledge differences scores were conducted using Mann Whitney U-test non-parametric analyses. Finally, based on the Mann Whitney U-test for the STEM knowledge understanding data, the U_{bvs} (=0) was not exceeding the critical value U_{cv} (=1), then the null hypothesis (a) was rejected, because there was a significant difference of STEM knowledge understanding before and after camp activity at level of significance 0.025. Furthermore, it was founded that students’ learning experience in booth activity influences their STEM knowledge understanding in creating solution ideas for the disaster. It gave clear evidence that the booth activity as one of camp activities gave great impacts to their STEM knowledge understanding.

C. The impact of STEM Camp Activity to Student’s Attitude toward STEM Interest, Agreement, and Perspective.

The impact of STEM camp activity to the students’ attitude toward STEM

interest was taken by collecting their attitudes toward some questions and statements in STEM Implementation Questionnaire that adapted from G. Knezek & R. Christensen (2009), and Arthur. L. White (2010).

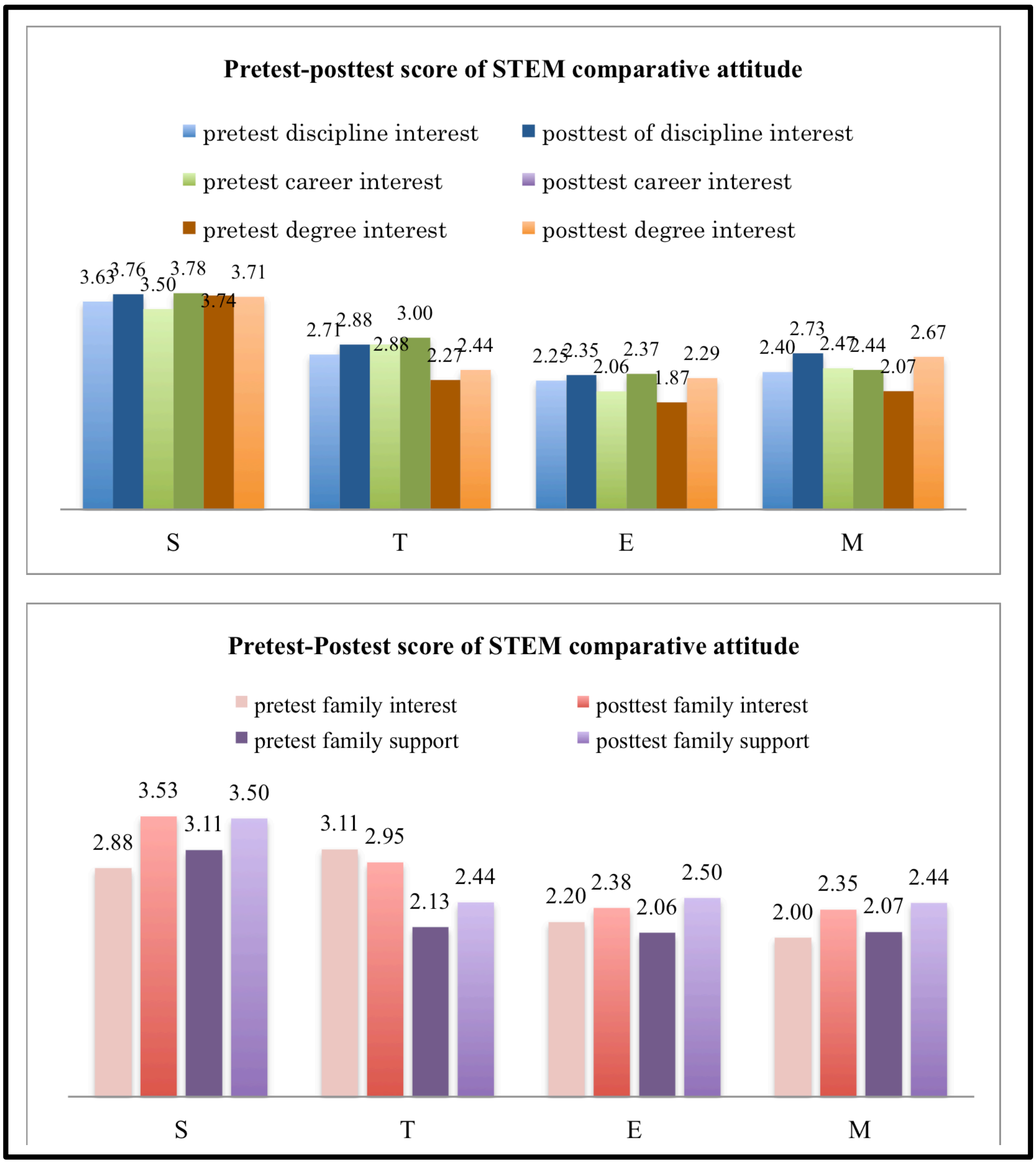


Figure 4.17: Students' Attitude toward STEM Interest

The STEM interests questionnaire consisted of five question that asked students to choose the comparative interest (most, more, less, and least) among science (S), technology (T), engineering (E), and mathematic (M). The STEM agreement questionnaire consists of seven statements that reflect their agreement toward STEM career, and STEM implementation in camp activities. The STEM perspective questionnaire was a semantic type that consists of 15 pair words that

asked about students feeling about STEM contents areas (see appendix E for the detail questionnaire). The students' attitudes were showed in the figure 4.17.

The results showed that there was a change in students' attitude before and after STEM camp activity, but the differences were not significant in some of interests and agreements. The perspective of STEM content also changed, and the differences were significant.

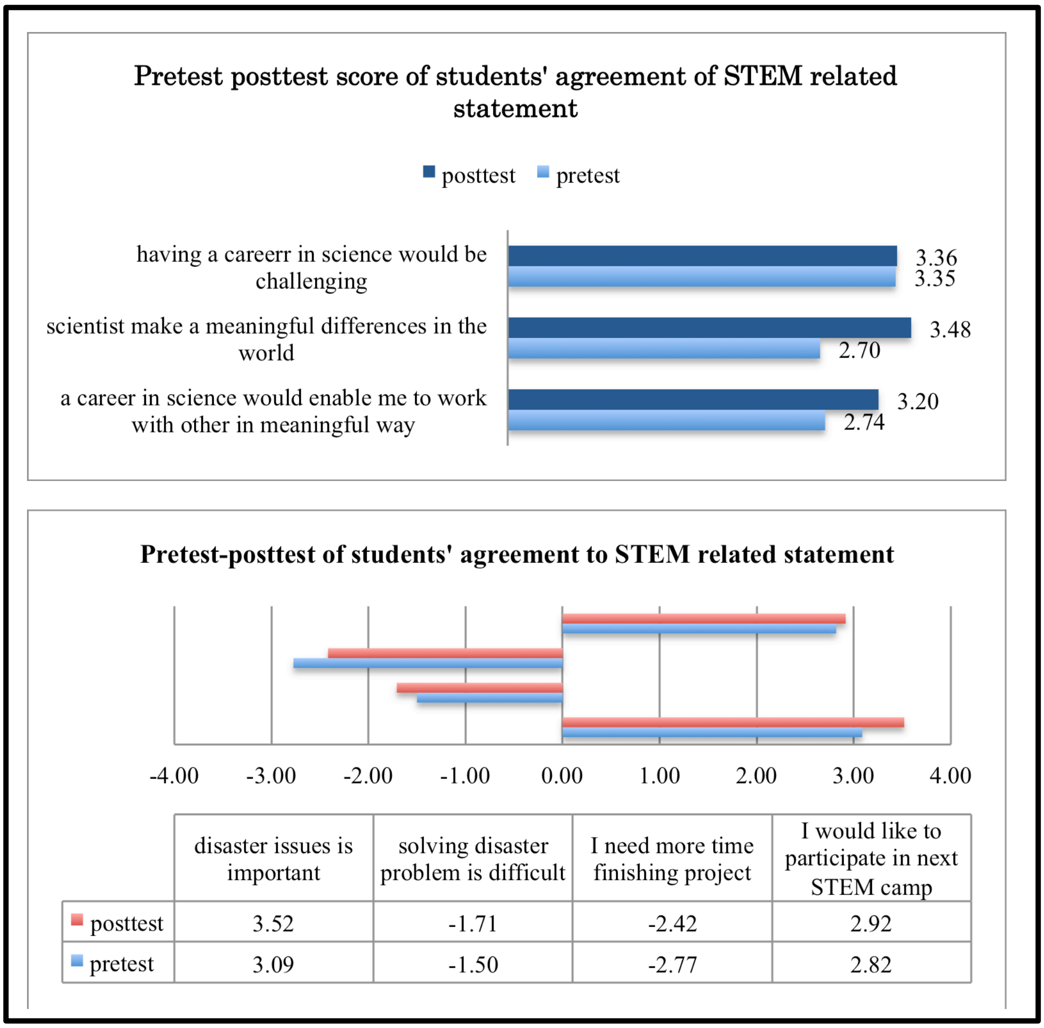


Figure 4.18: Students' Agreement to the Statement

In STEM interest, there were five criteria; discipline interest, career interest, family support, family interest and degree interest. The students' average score range from 1.87-3.78, it showed that the interest were range in between less to most criteria. In general, the students were most interest in science for all criteria, and then they were more interest toward technology than mathematics and

engineer. This fact showed that students and the family gives most support and interest for discipline, career and degree in science, but technology, engineering and mathematics seem less familiar for them.

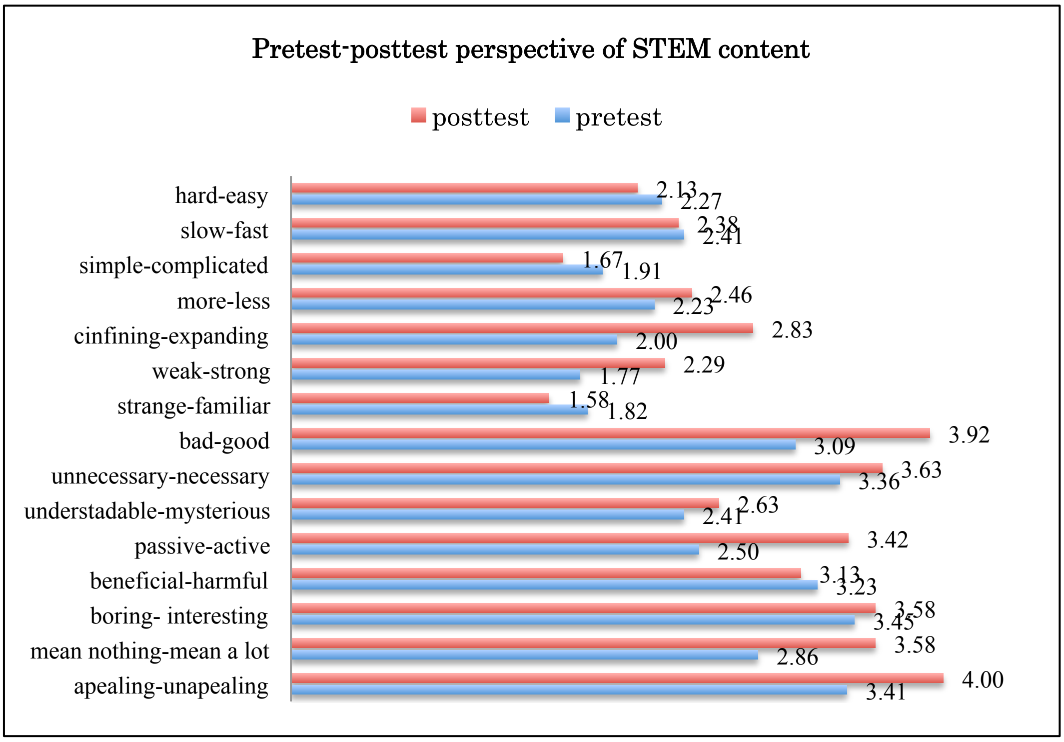


Figure 4.19: Students' Perspective of Stem Content

In STEM agreement, the scores ranged from -2.77 – 3.48. In average, they agreed that having a career in science would be challenging, scientists made a meaningful difference in the world, and a career in science would enable them to work with other in meaningful ways. Furthermore they also agreed that disaster issue was important and they would like to participate in the next STEM camp activities. On the other hand, they disagreed that solving disaster problem was difficult and they needed more time in finishing the projects. The last statement of time consuming in finishing project seemed contradictive to the fact in camp activities, where they spent long time in doing the activities.

In the STEM contents perspectives, it founded that they thought that STEM contents were less familiar, it was seen from lowest average score for this criteria (pre =1.82, post = 1.58). Moreover, they thought it was complicated that indicated from score pre = 1.91, post = 1.67. These showed that after camp activities they thought it was more complicated and less familiar than before camp activities. The other decrease perspectives were on 'hard-easy', 'slow-fast', and

'beneficial-harmful' pair words. In other words, they thought that STEM contents were harder, slower in development, and less beneficial. The highest perspectives score in average was in pair word 'bad-good', they increased their perspectives after camp, and they thought STEM contents was better than before.

The significance analyses were tested using t-test for dependent sample, the result shows in table 4.15. The t critical value was 2.060 at two tails test with alpha 0.05; it showed that the level of confidence to the analysis is 95%. The observed value of STEM perspective was 3.380 exceeded the critical value, thus the null hypothesis (b) for the perspective is rejected. But there were no different significantly for STEM interest and agreement before and after camp, thus the null hypothesis (b) for the interest and agreement are accepted.

Table 4.15: The T-Test Result of STEM Interest, Agreement and Perspective

Value	**Discipline interest**	**Career interest**	**Family support**	**Family interest**	**Degree interest**	**Agree ment**	**Perspe ctive**
SD	4.944	4.893	4.762	4.243	4.411	8.526	14.807
t_{ov}	0.989	0.979	0.9524	0.849	0.882	1.401	3.380
t_{cv}	2.06	2.06	2.06	2.06	2.06	2.06	2.06
signifi-cant	-	-	-	-	-	-	*

* The difference is significant at 0.01 levels

D. Consistency of Dominate Intelligence and its Characteristic.

The characteristics of multiple intelligences were observed during the camp activity. It was classified based on the activity purposes. For instance; 62.5% of social interpersonal and 14% of verbal linguist intelligence were observed during 'Bingo Card' activity, 72% of verbal linguist intelligences and 33% of body kinesthetic intelligence were observed during 'puzzle game' activity, 72% of logical mathematical and 25% of visual spatial intelligences were observed during 'making concept map' activity, 28% of verbal linguist, 25% of visual spatial, and 25% of social intrapersonal were observed during 'lecture' activity, 67% of body kinesthetic, 14% of logical mathematical, 12.5% of social intrapersonal, and 25% naturalist intelligences were observed during 'booth' activity. Furthermore, 28% logical mathematical, 33% naturalist, and 50% intrapersonal intelligences were observed during reconstruct concept map, 50% intrapersonal, 50& visual spatial, and 33% naturalist intelligences were observed during 'group discussion'

activities. The detail of observed characteristic during the camp activity was shown in table 4.16 below.

The observed MI characteristic of each student in a group was counted and compare to its multiple intelligences score, then was plotted in the chart diagram. Consistency of multiple intelligences self-estimate profile and the observed MI characteristic were analyzed from the chart and *r* value of Pearson Product Moment correlation. The results of comparison and correlation analyses were shown in Figure 4.20 and Table 4.9 below.

Table 4.16: Percentage of Observed MI Characteristic in Each Activity

No	Activity	Percentage of observed MI characteristic
1	Bingo Card	62.5% SI, 14% VL
2	Puzzle Game	72% VL, 33% BK
3	Making Concept map	72% LM, 25% VS
4	Lecture	28% VL, 25% VS, and 25% SI
5	Booth	67% BK, 12.5% SI, and 33% NI
6	Reconstruct Concept Map	28% LM, 33% NI, and 50% II
7	Group Discussion	50% II, 50% VS, and 33% NI
8	Sound Guessing Game	100% MR

The chart in figure 4.20 indicates that the A group students who were dominant in musical intelligence showed the same dominancy in observed MI characteristic, it implies that students' MI characteristic represented 83.75% of musical intelligences characteristic during camp activities. Furthermore, the B group students who were dominate in body kinesthetic intelligences, showed highest percentage of MI characteristic in body kinesthetic characteristic (90.63%). It showed the consistency between dominant multiple intelligences and its dominant MI characteristic. The other facts were seen from other groups. For instance, the C group students who were dominant in logical mathematical intelligence represented 82.5% of logical mathematical intelligences characteristic. And the D group students, who were dominant in verbal linguist and intrapersonal intelligences, showed highest percentage in verbal linguist characteristics during the camp activities.

The correlation between dominant multiple intelligence profile and those characteristics, were analyzed by calculating *R*-value of Pearson product moment between MI self-estimate score and observed MI characteristic scores. The table 4.17 showed positive correlation between MI self-estimates scores and observed

characteristic scores. A and D group had ‘high’ positive correlation, while the B group had ‘middle’ positive correlation, and the C group have ‘low’ positive correlation. Based on this fact, it concluded that null hypothesis (c) was rejected because most of students showed consistency of their MI self-estimates and their characteristics.

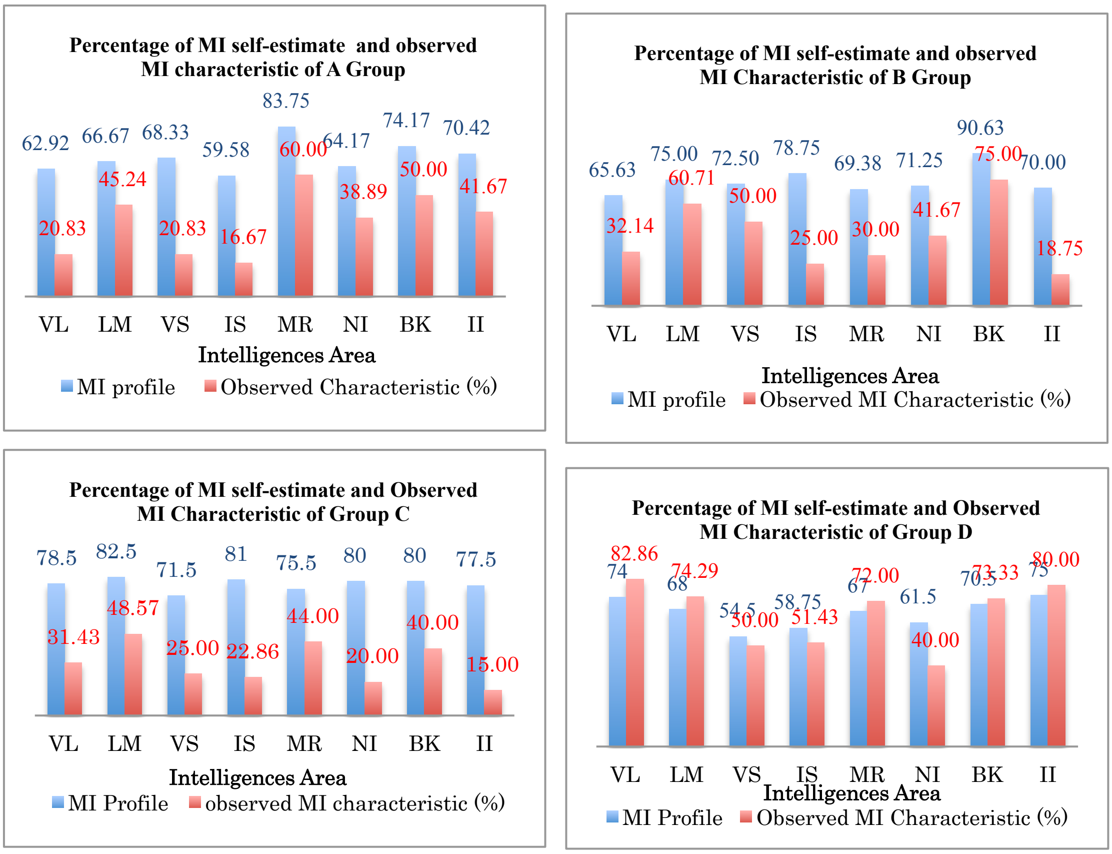


Figure 4.20: Diagram of Comparison between MI Self-estimate and MI Characteristic Percentage

Table 4.17: R-Value of MI self-estimate score and observed characteristic score

No	Group	r value
1	A	0.823
2	B	0.682
3	C	0.221
4	D	0.885

E. The Impact of STEM Camp Activity to the Self-estimate of Multiple Intelligences

Gardner viewed that intelligences could be developed through activities that provided students to improve their intelligences. Some of camp activities were design to improve students' multiple intelligences. But in fact, these activities were not enough to improve their multiple intelligences significantly. Even though it was not different significantly, but there was a difference in students' multiple intelligences self-estimate before and after camp activity. The differences of MI self-estimate scores and the Wilcoxon rank-test result were listed in table 4.18. Based on the results, it could be concluded that null hypothesis (d) was accepted; there was no significant difference of students' self-estimate of MI before and after camp activities.

Table 4.18: Average score of MI self-estimate and Wilcoxon rank-test value

Group	Average score pretest of MI self-estimate								Average score pretest of MI self-estimate							
	VL	LM	VS	IS	MR	NI	BK	II	VL	LM	VS	IS	MR	NI	BK	II
A	25.1	26.6	27.3	23.8	33.5	25.6	29.6	28.1	24.0	27.8	26.8	25.0	30.8	29.0	28.8	28
B	26.2	30	29	31.5	27.7	28.5	36.2	28	31.2	32.7	26.5	34.2	26	31.2	33.7	24
C	31.4	33	28.6	32.4	30.2	32	32	31	31	32.8	31	34.2	32.8	33.4	33.8	32
D	29.6	27.2	21.8	23.5	26.8	24.6	28.2	30	30.4	28.4	26.8	27.2	31.8	27.4	31.4	29
Sum	223.78								231.88							
d	8.1															
Wo	102															
Wcv	68 at p = 0.01															

F. The impact of STEM Camp Activities and Dominant Multiple Intelligences to Students' Creativity skill

There were some definitions of creativity. For instance, Brandt (1986) defined creativity as a personal way of using and directing your own abilities; Marianne. G (2010) d*efined creativity as the generation of new ideas either by new ways of looking at existing problems or seeing new opportunities*. Teresa Amabile (2005) wrote that creativity arose through the confluence of following three components: **knowledge:** *All the relevant understanding an individual*

brings to bear on a creative effort, ***creative thinking:*** *relates to how people approach problems and depends on personality and thinking/working style,* ***motivation:*** *motivation was generally accepted as key to creative production, and the most important motivators are intrinsic passion and interest in the work itself.* In this research, creativity skill was measured to see other impacts of STEM activity to this skill that one of important skill that needed in 21st Century. There were two ways analysis of creativity in this research; first, measure students' creativity skill profile, and second, analyze students' creativity from their solution design. The students' creativity skill profiles were taken using Torrance Test of Creative Thinking that was developed by Torrance (1966). The results were shown in the chart below.

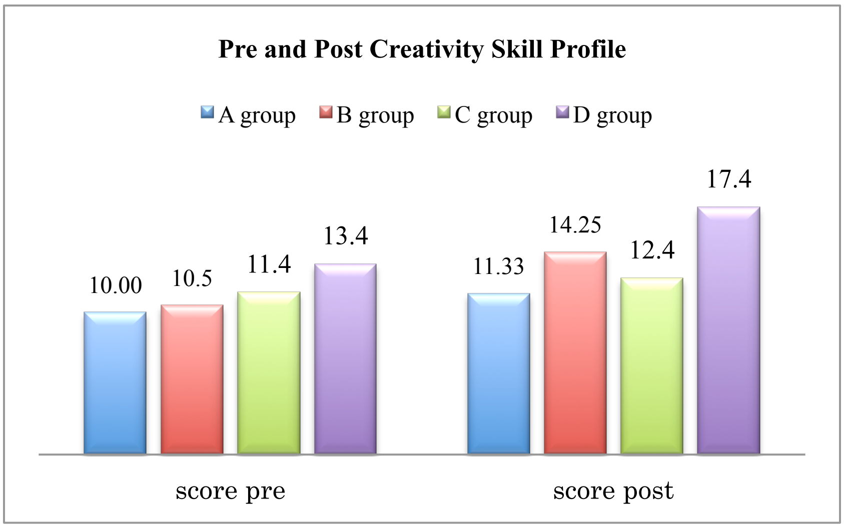


Figure 4.21: Students' creativity skill profile before and after STEM Camp Activity

The chart described students' creativity skill profiles based on their dominant intelligences. Before camp, the A group students who were dominant in musical intelligence got lowest (10.00) creativity skill average score than others group, the B group students who were dominant in bodily kinesthetic got average score 10.50 which is more creative than the A group, and the D group achieved highest score better than the C group achieved average score of 11.4. After camp activities, most of students' creativity skill increased, but some group showed lower increase than others. For instance, the A and C group students achieved $\pm$1.00 average score difference, and the D group students who achieved highest average score

(17.40), but the difference scores (3.00) was lower than the B group students (3.75).

The impacts of STEM activities into students' creativity skill profiles were analyzed from the difference scores before and after camp activities. The significance of the difference was tested using Wilcoxon rank test, and the results (see appendix E) showed there was a significant difference of creativity skills profiles before and after STEM activity in the level of confidence 95% at alpha 0.05, where the Wilcoxon observed value (W_{ov}= 60) did not exceed the Wilcoxon critical value (W_{cv}= 77). Thus, null hypothesis (e) could be rejected.

On the other hand, the impact of STEM activities and dominant intelligence to the creativity skills were analyzed from type of the solution design and the creativity score for each student in the group. The results were showed in table 4. 19. The scores of creativity skills were built in the rubric of creativity that adapted from NRC (2002) (see appendix C.2.2).

Table 4.19: Students' Creativity Skill on Designing Sustainable Community from Natural Hazard Disaster

Group	Type of design	Fluency	Flexibility	Originality	Abstractness	Total
A	Structure, building	1.17	1.00	1.33	1.17	**4.67**
B	Structure, building	1.25	1.25	1.25	1.25	**5**
C	Object, building, structure, tool	2	2.2	2	2.2	**8.4**
D	Tool, building	1.00	1.20	1.20	1.80	**5.20**
	H_{ov}			**-3.37**		
	χ^2			**7.815**		

To analyze the creativity skills in the solution design, all creativity criteria were analyzed such as the fluency, flexibility, originality, and abstractness. The fluency scores showed how various ideas in the design, the flexibility scores showed how vary the idea was, the originality scores showed how different the design, and the abstractness scores showed how clear the design. Table 4.19 showed that the C group students who were dominated in logical mathematical achieved highest scores of creativity skills because most of the students drew a complete, varied, and clear designs that dissimilar from the other groups (see appendix. E). Moreover, in general, it showed that 75% of design types were

'structure', 75% building, 25% object and 50% tool. 'Structure' designs varied in shapes and forms, building designs varied in heights and floors, the object was a human body, and then the tool was communication tools and wind turbine. In specific, the influence of dominant intelligences in the designs was found in the design type in answering the guided question before they designed the solution. There was one question of three questions, which could show the relevancy of dominant intelligence and solution design type. In answering the question how to predict the disaster, two students of the A group who were dominated in musical rhythmic intelligence, drew TV, radio, and phone accompanied with musical note symbol, which couldn't be found in the other group design. Furthermore, two students of the B group who were dominate in bodily kinesthetic, drew people who were transferring information and those processes, these showed they tended to use their part of body to solve problem, these relevant to their dominant intelligence and it was different from other group. However, the impacts of dominant intelligences into students' creativity statistically did not showed significant differences among groups, because the Kruskal Wallis analyses showed that H_{ob} = -3.37 that was not exceeded χ^2= 7.815.

G. Challenges in STEM Implementation

1. The Challenges in Implementing Technology and Engineering

The challenges were analyzed from seven elements of implementation evaluation; Integration of Science and Math, technology, engineering design, STEM professionals, link to career, what students are doing, and autonomy. Three STEM researchers evaluated it and conclude in the table 4.20

Table 4.20: Evaluation Result of STEM Implementation in 2014 Camp Activities

No	Elements	Categories
1	Integration of Science and math	Implementing,
2	Technology	Implementing
3	Engineering design	Implementing,
4	STEM professional	Emerging, non-STEM
5	Link to career	Emerging
6	What students do	Exemplary
7	Autonomy	Implementing,

2. The Using of STEM Context

The same evaluation strategy was applied in 2014 STEM Camp activities. The results were shown below.

Table 4.21: Evaluation result of 3Ps (Purpose, Program, Practice of 2014 Camp Activities

Dimension	Time	Participant	Location	Product	Problem	Agreement
Purposes						
Establishing goals for STEM Activities	It took more than one week	Actively engage faculty collogues, master students, and relevant community	Easy to be accessed	Goals related to STEM education purposes	The participant took less responsibility Took much cost	Fair
Dimension	Time	Participant	Location	Product	Problem	Agreement
Providing justification for STEM education	It took more than 6 month	Actively engage faculty collogues, and relevant community	Easy to be accessed	It seldom produce STEM education implementation evaluation instrument	The participant took less responsibility	Fair
Program						
Developing material or adopting a program for STEM	Took more than one month	Actively engage faculty collogues, graduate students and relevant community	Easy to be accessed, fair	Problem based learning instruction that related to civic phenomena	The participant took less responsibility, more	Fair, bad
Implementing the STEM program	Took less than one month	26 students; 21 elementary and secondary Japanese, 5 Indonesian secondary school students	Easy to be accessed At Yaizu Youth building	The product is related to civic phenomena solution that connected to STEM	The participant took less responsibility	Fair

Table 4.21: Continued

Practice (during 2014 STEM Camp)						
Changing teaching strategies for STEM	It took more than 4 month	Actively engage graduate students and relevant community	Easy to be accessed (at university)	Better teaching strategies scenario in STEM	It took more cost to the program conductor, fair	Fair, bad
Adapting materials to unique needs of teacher, schools, and students	It took less than 4 month	Actively engage graduate students and relevant community	Easy to be accessed (at university)	Produce fair unique materials that needed by mentor and students	The participant took less, responsibility, more	Fair, bad

Challenges in First Implementation of STEM education in Indonesia: Teacher's perspective of STEM Integration into Curriculum and Its Implementation in Learning Processes

The Indonesian government has published a new curriculum, called the 2013 curriculum. This is a revision of the previous curriculum because of the lack of competence of graduates, the excessively broad and irrelevant content, and the fact that it was teacher centered, textbook oriented learning, and used cognitively focused assessment. This revision was also triggered by the new challenges of the 21st century, an era of rich technology and information, that impact on modernization, globalization, science and technological development. This newly released curriculum is one strategy developed by the government to enhance educational quality in order to create qualified students to compete in an international world. The main purpose of this new curriculum is to build productive, innovative, creative, and good affective human, through a reinforcement of attitudes, skills and knowledge in order to face the challenges of the 21st century.

The government has not implemented this reform all regions; it has been carried out in specific area and responses are being collected from educational practitioners. Teachers criticize this curriculum because of the thematic content, which forces them to think holistically in order to teach lessons. In other words, teachers need to integrate all subjects into a lesson to achieve the core competencies in students. In fact, the answer to what is the best methodology to

achieve the purpose of the curriculum has not been studied yet. However, the integration science and technology plays an important role in creating the citizenry needed in this century (Furner &Kumar, 2007). Thus, implementation of STEM education has been chosen as a methodology to achieve these purposes. It is assumed that STEM education will improve students' literacy in science and mathematics. The first step in its implementation is teacher training to develop teachers' perception of STEM education, and then apply it in learning processes.

The purpose of this research is to investigate the challenge of STEM education implementation in Indonesia. It conducted in junior high school started with teacher training and it applications in learning process.

<u>Methodology:</u>

The teacher training were conducted in five meeting schedule, from 21st December 2013 until 18 January 2014. The first meeting was focused on explaining 2013 national curriculum and STEM education perspective. The second meeting was focused on STEM activity of '*design teaching and constructing*' (DCT-1) that asked teacher to make a balloon powered car from provided materials. The third meeting was focused on STEM activity of '*revise engineering'* (RE) that asked teacher to bring kid toys to analyze the work and made new design of the toys. The fourth meeting was focused on discussing lesson plan to apply STEM education into classroom. The fifth meeting was focused on discussing application result and STEM activity '*designing constructing and testing'* (DCT-2) that asked teacher to create paper bridge. Class implementations were conducted in one elementary class and one secondary class. Theme of lesson is 'momentum' in elementary class and 'motion' in secondary class. After evaluating teacher-training result, it was decided to do more class implementation in secondary level in order to study the impact of integrated MI approach into learning processes.

<u>Null hypothesis:</u>

a. There is no significant difference on teacher perspective before and after STEM education training activities.

b. There is no significant difference in the score of teachers' self-reflective at each STEM activities.

c. There is not positive response from students toward STEM education implementation into learning process

d. There is no significant difference of students' achievement on STEM education implementation with and without considering multiple intelligences profile.

Research Questions:

a. What are the impact of STEM education training to teachers' perspective on STEM integration into KTSP and 2013 national curriculum?

b. What is the impact of the training on teachers' self-reflective toward STEM education?

c. What is students' response to STEM education implementation into learning process?

d. What is the impact of multiple intelligence approach in STEM education implementation?

e. How is students' creativity skill in designing solution for 'flood' issues?

f. What is the challenge in STEM education implementation?

Result:

A. Teachers' Perspective on STEM Education Integration into Curriculum

After an introduction to STEM education perspective, teachers were asked to analyze whether or not STEM could be integrated into their curriculum. They were requested to read the science and math content and analyze whether or not it could be integrated with STEM. The integration of STEM is built on thinking to coordinate, complement, correlate, combine, and connect the disciplines (Bybee, 2013). It consists of three steps; 2.0, 3.0 and 4.0 integration. First through third grade elementary teacher analyzed the 2013 curriculum, and fifth through sixth grade teachers analyzed the KTSP curriculum. To measure teachers' perceptions before and after the training, they were asked to fill out the STEM Semantic Survey (SSS) that adapted from Berlin &White (2010) and Tyler-Wood, Krezek, and Christensen (2010). The SSS measure teachers' perceptions of STEM in three

areas: each discipline, the career and integration. Internal consistency reliability for each areas ranged from alpha = 0.81 to alpha = 0.93. The SSS consisted of six areas of perceptive that included 35 semantic pairs. The last three pairs refer to feasibility of integration (simple-complicated, slow-fast, and hard-easy) and were scored differently from the other pairs. The data were analyzed separately based on area of perception. Perceptual differences before and after training were statistically analyzed using a non-parametric test for dependent samples, the Wilcoxon Rank Test. The critical value of W was ranked from 8 to 14 at p = 0.05 (two-tailed tests). The results are shown in tables below.

Teachers' perceptions of 2.0 STEM integration is shown in Table 4.22, which describes several example of integration that can be applied to the content of the 2013 curriculum for first to fourth grade science and mathematics subjects by using some theme or sub theme for each grade. First grade teachers responded that integration could be achieved 1) by complementing ST within the theme "my healthy clean environment"; 2) by correlating of SM with the theme "my healthy clean environment", "animals and plants in my surrounding"; and 3) by complementing, correlating and coordinating EM with the theme "my experiences". Furthermore, second grade teachers responded that ST, SE, SM, TE, TM and EM could be integrated by coordinating, complementing and correlating them in correlated, complemented and coordinated with the theme "preparing and celebrating family occasion time".

In fact, third grade teachers responded that integration could be achieved by complementing ST with the theme "technology" (sub-theme: "sun as a light and heat source", and "use of energy in technology"), and coordinating and correlating SE and SM only with the sub-theme "inventor", and "motion in technology". Fourth grade teachers responded that integration could be achieved by coordinating ST and SE and correlating SM with the theme of "appreciating heroes" for the sub-theme "sound". Contrary to the 2013 curriculum, STEM cannot be integrated with all subjects in KTSP but for some specific subject matter. Fifth grade teachers wrote that they coordinated "simple mechanics" with ST, SE and SM, complemented "energy" with TE and correlated it with ST, " the earth and universe" with SE, "velocity" with SM, "simple mechanic" with TM and "light" with EM. In addition, sixth grade teachers complemented ST with "electrical circuit", SE with "making traffic light", SM with "simple mechanics", TE with "conductors and isolators", TM with "heat", and EM with "geometry".

Finally, secondary teacher thought that they can coordinate, complement, correlate and connected all integration in theme of simple mechanic.

Table 4.22: Content Analysis of 2.0 STEM Integration

Curriculum	Grade	STEM Disciplines	Coordinated	Complemented	Correlated	Connected	Theme/subtheme/ subject matter
2013	1st	ST		✓			*My healthy clean environment*
		SM			✓		*My healthy clean environment, Animals & plants in my surroundings*
		EM	✓	✓	✓		*My experience* *My healthy clean environment*
	2nd	ST	✓	✓	✓		*Preparing and celebrating family occasions*
		SE	✓	✓	✓		
		TE	✓	✓	✓		
		TM	✓	✓	✓		
		SM	✓		✓		*Preparing family occasions*
	3rd	ST		✓			*Sun as a light and heat source, and use of energy in technology*
		SE	✓		✓		*Motion in technology* *Inventors in technology*
		SM	✓	✓	✓		
	4th	ST	✓				*Appreciating heroes:* *Sub theme: sound*
		SE	✓				
		SM	✓		✓		
KTSP	5th	ST	✓		✓		*Simple mechanic* *Energy*
		SE	✓		✓		*The Earth and universe*
		SM	✓		✓		*Simple mechanics* *Velocity*
		TE		✓			*Energy*
		TM			✓		*Simple mechanics*
		EM			✓		*Light*
	6th	ST		✓			*Electrical circuits*
		SE		✓			*Making traffic lights*
		SM	✓	✓			*Simple mechanic*
		TE		✓			*Conductors and isolators*
	Secondary	ST	✓	✓	✓	✓	*Simple mechanic*
		SE	✓	✓	✓	✓	
		SM	✓	✓	✓	✓	
		TE	✓	✓	✓	✓	

Table 4.23 presents the teachers' analysis of the integration 3.0 STEM disciplines based on the curricular content. They read all science and mathematics subject theme, and thought about possibilities for integration with three STEM disciplines.

Table 4.23: Content Analysis of 3.0 STEM Integration

Curriculum	Grade	STE	SEM	TEM	MTS	Theme/ subject matter
2013	1st		Theme.2		Theme.2	Theme 2: Clean and health environment
	2nd	Sub.2	Sub. 2,3	Sub. 2,3	Sub. 2,3	Theme: Family time Sub 2: Prepare family event Sub 3: Celebrating family events
	3rd	Sub.2			Sub.1	Theme: Technology Sub 1: Inventor Sub 2: Motion in technology
	4th		Sub.3		Sub.2	Theme: Sound Sub. 2: Sound properties Sub 3: Music instrument
KTSP	5th	Matter 1	Matter 2	Matter 3	Matter 4	Matter 1: Light Matter 2: Earth and universe Matter 3: Energy Matter 4: Sound
	6th	Matter 1	Matter 2	Matter 3	Matter 4	Matter 1: electricity Matter 2: force and motion Matter 3: geometry Matter 4: velocity
	Secondary	Matter 1	Matter 2	Matter 3	Matter 4	Matter 1: Energy Matter 2: Heat and Transfer Matter 3: Social Arithmetic Matter 4: simple mechanic

The results showed that they were able to integrate several 3.0 STEM disciplines in one theme in the 2013 curriculum, but they were only able to integrate one variation of a 3.0 STEM disciplines with one subject (chapter) in KTSP. In the 2013 curriculum, for instance, first grade teachers proposed the integration of SEM and MTS with the "my health and clean environment", second grade teachers integrated STE, SEM, TEM, and MTS with the theme "family time" for sub-theme 2 and 3, third grade teachers chose the theme "technology" with the sub theme "motion in technology", and The sub-theme "inventor" to integrate with STE and MTS, and fourth grade teachers chose the theme "sound" for integration with SEM and MTS.

In KTSP, for instance, fifth grade teachers perceived that STE integration would be appropriate with “light”, SEM with “the earth and universe”, TEM with “energy”, and MTS with “sound”, while sixth grade teachers felt it would be appropriate with “electricity”, SEM with “force and motion”, TEM with “geometry, and MTS with “velocity”. And finally, secondary teacher thought STE would be appropriate with ‘energy’, SEM with ‘heat and transfer’, TEM with ‘Social Arithmetic’, and MTS with ‘simple mechanic’.

After analyzing the curriculum content and possibilities for integration with three STEM disciplines, teachers were asked to think of an example of full integration of STEM. Table 4.24 presents the result: First and second teachers presented a brief idea about full STEM integration without a clear example, while fourth grade teachers gave an example with a short explanation of disciplinary content related to the example. In fact, third, fifth, sixth and secondary grade teachers did not have any ideas for full integration.

Table 4.24: Content Analysis of 4.0 STEM Integration

Curriculum	Grade	Example
2013	1st	Subtheme: Objects and their changes Science: Knowing objects and their surrounding Math: Counting operations, geometry, and planes Engineering: Copying and drawing planes Technology: Finding tools that can change object shapes
	2nd	Subtheme: Energy Science: Heat, light and sound Technology: Bring tools that produce heat, light or sound energy Engineering: Creating sound with simple equipment Math: Multiplication/product
	3rd	No idea
	4th	Create telephone toys Science: Waves Technology: Produce telephone toy Engineering: Designing the toys Math: Measure string length and distance
KTSP	5th	No idea
	6th	No idea
	Secondary	Lever rules

The impact of training on teachers was assessed through the SSS questionnaire that teacher completed before and after training. The method of

analyzing teachers' perceptions toward disciplines and STEM career was adopted from Berlin and White (2010). It was scored 5, 4, 3, 2, and 1 for positively directed word pairs (e.g. exciting-unexciting), and 1, 2, 3, 4, and 5 for negative directed word pairs (e.g. mean nothing-mean a lot). Perception of feasibility was scored differently. It was recoded to assign the number five to responses reflecting the most realistic attitude and perception related to the implementation of integration in the classroom. For pair "simple-complicated" the remaining recodes were distributed so as to account for slightly higher scores for attitudes and perceptions related to challenges associated with integration (1 3 5 4 2). The pair "slow-fast", it is encoded (2 4 5 3 1). The pair "hard-easy", was encoded (2 4 5 3 1). Results show that the perception of technology is not different significantly (W (10) = 10, $p > .05$) but other areas were significantly different (W value range from 3 to 14, with critical value range from 5 to 14 at $p < .05$).

Table 4.25: Wilcoxon Rank Analyses Result

Perception	N	Mean Post- and Pre –test rank	W critical	W value
Science	10	3.54	8	3
Mathematics	11	5.3	11	8
Engineering	11	7.07	11	3
Technology	10	3.96	8	10
STEM Career	12	5.10	14	7
STEM Integration	12	3.57	14	14

Besides the SSS questionnaire, teachers were asked to decide their attitude toward statements that lists in Likert-Type questionnaire. The percent of agreements were shown in table 4.26. The statements were divided into three categories: STEM interest (1-3), STEM perception (4-11), and STEM training reflection (12-16). In general, most of teachers put positive agreement toward STEM education implementation, they perceived that STEM education implementation was applicable, easy to do and they agreed the STEM integration was not hard to do, and they suggested the continuous training in STEM education.

Table 4.26: Teachers' Agreement toward STEM Education Implementation

No	Statement	%			
		VA	A	DA	VDA
1	I eager to implement STEM education in class	100	0	0	0
2	STEM education can develop students activity	75	25	0	0
3	STEM are important knowledge for student to face 21st Century	31.25	56.3	6.25	0
4	Applying STEM Education is impossible to do	0	6.25	56.25	37.5
5	STEM education can be applied in any level	37.5	56.3	6.25	0
6	STEM integration is hard to do in class	6.25	6.25	87.5	0
7	Integration of STEM education is easy to do	6.25	81.3	12.5	0
8	Integration Science and Math is easier than with technology	12.5	50	37.5	0
9	To correlate science and mathematics is very hard	0	12.5	68.75	12.5
10	To connect science and engineering is impossible	0	0	81.25	18.75
11	To connect science and technology is hard to do	0	6.25	87.5	6.25
12	Deep knowledge of science and math are needed to implement STEM Education	25	68.8	6.25	0
13	Cooperation among science collogues will make STEM implementation easier	50	50	0	0
14	Science and Math concept enrichment program is really needed for me	56.25	43.8	0	0
15	STEM education training can increase my professionalism	62.5	37.5	0	0
16	STEM Education training should do periodically	56.25	43.8	0	0

Table 4.27: t-Test Analysis of Japanese Teachers' Perception

Perception	N	d	t critical	t value
Science	43	3.54	1.96	0.069
Mathematics		-98		1.0504
Engineering		126		1.099
Technology		90		1.169
STEM Career		57		1.093
STEM Integration		215		2.568*

* significant at 0.05 significance level

On the other hand, socialization of STEM education at teachers level also did in Japan. Forty-three teachers joined the lecture of STEM education perspective in the context of Japan. The impact of lecture to teachers' perspective of STEM education was analyzed from the significant difference before and after lecture. It was analyzed statistically using paired t-test for dependent sample. The results

were shown in table 4.27. The result showed that the teachers' perspective of STEM integration was different significantly before and after the lecture.

B. Teachers' Self-Reflective on STEM Education Implementation

Teachers' self-reflective on STEM education implementation was collected after STEM activities during the training program. It was collected by self-reflective question related to the STEM activities. The questions were; 1) what did you learn? 2) What problems did you face to learn? 3) How did you solve the problem? Those questions measured: teachers' understanding, define problem skill, and problem solving skill. It was scored using self-reflective assessment rubric in PBL (see appendix C). The variance of three activities was analyzed using non-parametric Kruskal-Wallis variance analysis. The results were shown in table 4.28.

Table 4.28: Kruskal-Wallis One-way variance analysis of teacher's self-reflective toward STEM activities

STEM activities	Understanding	Define Problem	Solve problem
Rank sum DCT-1	372.5	404	364
Rank sum RE	480	535.5	479
Rank sum DCT-2	372.5	285.5	419
H value	5.19	14.15	13.68
χ^2		5.991	

The results showed that there was significant difference of define problem and solving problem skill among teachers during STEM activities, but there was no significant different of teachers' understanding during STEM activities. Thus, the null hypothesis (b) can be rejected.

C. Students' Responses to STEM Education Implementation

STEM education implementation in the learning process, was conducted by selected teachers who joined the training. It was selected based on the curriculum content analysis results and lesson plan that appropriate to integrate the STEM education. The students' responses were collected by an interview that consisted

of several questions; how students' responses toward the lesson were, how was students' activity today, and what did they learn. The interview results were shown in table 4.29.

At the elementary level, the theme of STEM education implementation was 'friction'. The teacher asked students to analyze what would happen if the ball slides in the different surface. The purpose of this lesson was to understand the friction force that was influenced by the surface condition. The students' interview results toward this lesson showed that almost all students enjoyed the lesson; they said happy to join the lesson, 75% students moved actively, engaged to the lesson and did the activities, but 75% of them said that they didn't much understand the lesson.

Table 4.29: The Interview Result

Question	Today lesson is		
Students	Interesting	Boring	Mundane
Elementary	100%		
Secondary	100%		
Question	Today lesson make me:		
Students	Move actively	Think actively	Doing nothing
Elementary	75%	25%	
Secondary	90%	10%	
Question	I understand the lesson		
Students	All part	Some part	Didn't understand
Elementary	25%	75%	
Secondary	29%	80%	

At the secondary level, the first implementation took a theme of 'motion', the teacher ask students to create balloon-powered car from provided materials and then test the motion of the car. The purpose of this lesson was to understand the linear motion. By identifying the characteristic of linear motion, the interview results showed that almost all students were enjoying the lesson, for interview results they said they are happy to join the lesson, 90% students were move actively in lesson, engaged and did activities that teacher ask to do, and 80% students were understand of motion, distance and displacement, but they confused of linear motion concept because some of their data did not show those characteristics.

D. The Impact of Multiple Intelligences Approach in STEM Education Implementation.

The samples in this study were first grade of secondary students in Primary and Secondary Muhamadiyah 8. The first implementation was conducted during teacher training program. The second implementation was conducted a month after teacher training program. The first learning processes took a topic of ‘motion’, teacher asked students to measure and analyze the linear motion characteristics from a balloon-powered car that made by them. The second implementation took topic of ‘living thing classification’, teacher asked students to observe the living things in school neighborhood, students were grouped based on the dominant intelligence. Teacher gave freedom for students in finding the information by direct observations or web searching. The impacts of learning processes into students’ achievement were analyzed from students’ achievement at the examination results. It was compared to the students in control class who did not use MI and STEM integration approach. The comparisons were limited only in the item problems in examination that related to the topic that integrated STEM, that was ‘motion’ and ‘living things classification’ item problems.

Table 4.30: t-test Result of Control-Experiment Class

Class	Control	Experiment	t-score
Average of total examination score (Non-STEM and STEM class)	74.33	77.93	0.251
Average of STEM integration related item (Without and With MI approach)	5.467	5.69	0.435
t- critical	2.045 at p =0.05		

Table 4.30 showed that t-score for total examination scores and STEM integration related items did not exceed the critical value, thus the null hypothesis was accepted. There was no significant difference between learning process that integrate STEM and MI approach and the learning process without it. But, generally the average scores of total examination and STEM integration related items were different in both classes. It showed that students who have used STEM integration and MI approach achieved higher average score than students who did

not used it. On the other hand, the impact of learning processes in the class that using MI approach, showed significant difference of multiple intelligence profiles in one semester. It was showed in table 4.31.

Table 4.31: Multiple Intelligence Profile in One Semester

Intelligences	NI	MR	LM	VL	VS	SI	BK	Mean	t-score
At the beginning of semester	49	46	21	26	26	55	28	8.66	7.967
At the end of semester	55	58	24	36	33	64	40	10.69	
t-critical	2.045 at p = 0.05								

E. Students' Creativity in Designing the Flood Solution

Project Based Learning (PBL) approach in STEM education implementation took place in second semester. These activities presented in the form of competition, and aims to enhance student interest and knowledge of STEM education and career. These activities challenged students to compete in the creative and innovative ideas. Target of sample for these activities were first and second grade of secondary students in Primary and Secondary Islamic School Muhammadiyah 8 Bandung. Students were challenged in a STEM project to solve 'flood' problem that was a big issues in Indonesia during the rainy season. The project was designed for one semester, and the discussion was conducted once in a week.

The project issued to all students and parents in special event that conducted at the end of the first semester. Most of students and parents were enthusiast, but in fact, only 13 students who were proposed their solution design. The proposal solution design were judged and presented in front of STEM teachers. Most of students' solution designs were related to alarm sensor, they designed a flood detector to prevent the flood disaster. The creativity of solution designs was judged from the fluency, flexibility, originality, and abstractness of the design. Fifth students were selected as the most creative as others, and they continued the

project by making the prototype of their design. Results of students' creativity were presented in table 4.32.

Table 4.32: Students' Creativity in Designing the 'Flood' Solution

Student	Type of design	Fluency	Flexibility	Originality	Abstractness	Total
A	Flood detector pipe	2	1	1	1	**5**
B	Flood detector from used materials	2	3	2	2	**9**
C	Water absorber	3	2	3	2	**10**
D	Flood detector tower	2	2	1	2	**7**
E	Flood detector	2	2	1	2	**7**
F	Flood detector	2	1	1	1	**5**
G	Water absorber & flood detector, & recycling water	3	3	3	2	**11**
H	Flood detector 3 LED pipe	2	2	1	2	**7**
I	3 alarm flood detector pipe	2	2	1	2	**7**
J	Flood detector pipe	2	1	1	2	**6**
K	DAM	2	2	3	1	**6**
L	Gutters' cover plate & flood detector & recycling water system	3	3	3	3	**12**
M	Photovoltaic flood detector	3	3	2	2	**10**
	Average	2.31	2.08	1.77	1.85	7.85

Generally, the students were fluency and flexible in solving the flood problems. It showed from average scores that higher than other categories. However, the originality of the solving problem was lower than other categories because most students had common ideas.

F. Challenge in STEM Education Implementation in Indonesia

STEM education implementation challenge in Indonesia is focused on class implementation evaluation. The evaluation is based on the rubric that have same element but different category that develop to evaluate the STEM implementation in Japan. Three STEM researchers did the evaluation; the results are shown in table 4.33 and 4.34.

Table 4.33: Evaluation Result of Technology and Engineering Integration in Indonesia

No	Elements	Categories	
		Formal	Informal
1	Integration of Science and math	Emerging,	Implementing
2	Technology	Non STEM,	Emerging
3	Engineering design	Emerging,	Exemplary
4	STEM professional	Non-STEM	Non-STEM
5	Link to career	Non-STEM,	Emerging
6	What students do	Implementing	Exemplary
7	Autonomy	Emerging	Implementing

Table 4.34: Evaluation Result of the 3Ps in Learning Processes

Dimension	**Time**	**Participant**	**Location**	**Product**	**Problem**	**Agreement**
			Purposes			
Establishing goals for STEM Activities	Less than 1 week	Only collogues	Easy to be accessed	Related to STEM education purposes	Integrate it to the curriculum	Good
Establishing priorities for STEM goals in the STEM activities	Less than 1 week	Only collogues	Easy to be accessed	Imply the first purposes of STEM education	Analyzing the standards in curriculum	Good
Providing justification for STEM education	More than 1 year	Collogues and parents	Easy to be accessed	Evaluation of the program	Lack of resource and STEM professional	Good

Table 4.34: Continued

Dimension	Time	Participant	Location	Product	Problem	Agreement
			Program			
Developing material or adopting a program for STEM	More than one month	Collogues, students, and parents	Easy to be accessed	Learning Instruction	Providing materials	Good
Implementing the STEM program	More than one month	Collogues, students, and parents	Easy to be accessed	Students' achievement	The participant took much responsibility	Good
			Practice			
Changing teaching strategies for STEM	More than one month	Collogues, students, and parents	Easy to be accessed	Better teaching strategies	It took more cost to the program conductor (the school)	Fair
Adapting materials to unique needs of teacher, schools, and students	More than one month	Collogues, students, and parents	Easy to be accessed	Produce simple materials that needed by teacher, schools and students	It took more cost to the school	Fair

CHAPTER V
INTREPETATION AND DISCUSSION

INTRODUCTION

This chapter discussed the challenges of different STEM education implementation methods by interpreting the research results that conducted in two countries. It consisted of three sections; the first section discussed the cultural setting diversity through the multiple intelligences (MI) profiles difference analyses among Japanese and Indonesian students, the second section discussed STEM education implementation results that derived from different implementation method based on each educational systems goals, and the third section discussed the challenges analyses in STEM education implementation.

CULTURAL SETTING DIVERSITY
Multiple Intelligences Profile Study

Japan and Indonesia, the two Asian countries, located in different geography condition. Each country has its own history of education that influences the individual cultural setting. It was seen from the way they estimate their self related to the multiple intelligences.

The first studies of analyzing multiple intelligences profiles between both countries were conducted at the undergraduate level. This study was undertaken to analyze the science and mathematics undergraduate students' MI profiles in order to find out which were the most and the least developed intelligence area on science and mathematics students. The samples were undergraduate students in math and science faculty. The results showed that average scores in each intelligence area were different. However, not only profiles of intelligences were different significantly, but also logical mathematical intelligence were different significantly in both countries. *Logical mathematical intelligence was the ability to solve problems mathematically and logically, to question, to hypothesize and to carry out complex mathematical operation* (Gardner, 1999). The differences occur because of the diverse subject matter that gained by students in each science major. It also could be seen in the science curriculum for science student in both countries.

In Indonesia, every major has required 144-150 credits to finish studying (UPI Curriculum, 2010). They are divided into four course criteria: general, basic profession, expertise profession, and field professional courses. The contents of each major differ especially in expertise professional course. It is separated into two criteria: on faculty expertise and major/program study expertise.

The samples in this study were first semester students. They had the same faculty expertise courses but different program study expertise courses. For instance, mathematics students had to take English Language and Calculus 1 course as their program study expertise. Other majors such as physics take Mathematic Physics course, chemistry and biology students had to take Basic Lab Technique course and computer science students had to take Introduction to Information Technology course besides the English Language course. These contents differences lead to distinct logical intelligence score. Math students were taught more mathematics subject that consisted of mathematical theory and it trained student mathematics logical thinking. Physics student also instructed more mathematics in Mathematics Physics subjects. They taught physics theory in mathematical terms, it trained them to think of physics mathematically, thus they estimate their own logical mathematics intelligence was developed higher than chemistry, biology and computer science but lower than mathematics students.

In Japan, Shizuoka University curriculum emphasized that physics students studied physics and mathematical methods through a wide range of practical training centered on lectures in mathematics and basic science with the goal of becoming skilled, dedicated professionals in fields ranging from electronics and information to academia and teaching. On the other hand, chemistry students developed direct knowledge through a curriculum of stressing experimentation, especially in a wide range of chemistry, including organic, inorganic and analytical chemistry, biochemistry, structure and physical chemistry, and chemical reaction dynamics. Biology students studied biological science from an integrated perspective centered on the principles of life, and the diversity and environmental adaptation of living organisms, using a systematic approach that ranges from DNA to collections of organisms, and geology students explored a wide variety of geoscience phenomena, including earthquakes, volcanism, magma, crustal movement, metamorphism, and plate tectonics, with many opportunities to get out and collect data and samples. It showed that logical mathematics thinking skills trained differently for each major. It could be seen in Table 4.3 that logical

mathematics intelligence scores of physics students > chemistry > biology >geology students. It seemed that most trained the mathematical thinking most developed the logical mathematical intelligence was. These findings agreed with Baum et al. (2006) who stated that *an individual's intelligence develops and changes based on interaction with the environment* (people, resources, and so forth).

Besides the curriculum, cultural aspects also impacts on the differences. Lay theories of intelligence suggest that there were subtle but important differences in the way in which (traditional) cultures define intelligence (Furnham, 2001). On the other hand, Lynn (2006) said that intelligence differences were determined by genetics and environmental factors. This assumption had argued by Ossorio (2006), who argued that there was no evidence to support the assumption that current racial differences in mean of IQ scores were caused by racially distinctive patterns of genetic variation. It could be concluded that intelligence differences were determined by the environment included the cultural aspects.

The further study was conducted in middle school students. The results showed that Indonesian students were dominated in intrapersonal intelligence, and Japanese students were dominated in bodily kinesthetic intelligences. Moreover, Japanese students estimated their logical mathematical, existential, social interpersonal and intrapersonal intelligences lower than Indonesia significantly.

These studies showed that Japanese students estimated their own logical mathematical intelligence score lower than Indonesian. This were intriguing and unexpected result, because it was assumed that students from Japan, as a technology oriented country and more developed than Indonesia, have a higher self-estimate score than Indonesian. This showed that even though they were Asian but they had a different ways to define the intelligences. Lynn (1982, 1993) said that the *Japanese are the most self-deprecating about their intelligence despite there being ample evidence of their overall high ability on test*.

These results supported the Furnham and Baguma (1999) study that found a significant national difference in the mean score for estimates Gardner's (1999) seven intelligences as well as on three domain scores; verbal (verbal, interpersonal, intrapersonal), numerical (mathematical, spatial) and cultural (musical, body kinesthetic). American participants gave themselves the highest overall IQ rating followed by the British and then Japan. Japanese ratings for self and children would be more modest (lower) than ratings by parents in other European nation.

This was because of culturally the Japanese value modesty in both sexes as a highly desirable trait (Furnham, Hosoe, et al, 2002). Studies using Chinese parents from Hong Kong had also showed the Chinese more modest in their estimates compared with European and American groups (Furnham, Rakow, et al, 2002). Other research is conducted to Singaporeans (all of the Chinese ethnic group) showed the same result compared to Britons. He (Furnham, 1999) assumed this was evidence that Asians tended to show humility in their self-estimations of the seven Gardner intelligences.

Furthermore, A Furnham (2001) studied about general (g) and multiple intelligences (MI) self-estimate that conducted in America, Britain and Japan. It was reported that American gave consistently higher rating than Japanese. He suggested that this maybe more explicable in terms of Japanese humility or modesty rather than American hubris. The 'modesty bias' had been reported in various studies conducted with Asian participant. Smith and Bond (1998) had noted that Asia tended to be shown modest effects (self-effacing biases) for ability ratings and hubris effects (self-serving biases) for effort ratings. The Japanese was the most modest people, even among Asian. They rated their intelligence lower than other. It might be because of cultural settings among Japanese that they should be modest and put respects to other people. However, this data was not judge students' intelligences that measure by numeric questions, it analyzed how students estimate their self to their intelligences. A. Furnhan (2001) also suggested that his research should not be seen as attempts to validate Gardner's (1983, 1999) theory, although it surely required robust empirical assessment. Rather they represented attempts to better understand lay theories about intelligence (Flugel, 1947; Sternberg, 1990) and how they might relate to expectations, evaluations, and performance on ability tests of all kinds (Beyer, 1999; Halpern, 1997; Lynn, 1994).

Based on the research result, it could be generalized that Japanese students were more modest in estimating their intelligences than Indonesian students. In general, they dominated in bodily kinesthetic, while Indonesian students were dominated in intrapersonal intelligence. Furthermore, the most significantly different among intelligences in both countries were logical mathematical intelligences. Thus, it should be considered that the activities should be related to the dominant intelligence without ignoring other less developed intelligence.

ANALYSIS OF STEM EDUCATION PRACTICE USING MULTIPLE INTELLIGENCES APPROACH

STEM Education Implementation in Japan

Teachers and students were two correlate components that became the main consideration in educational systems. The scholastic system was developed based on national education goals that changes refer to the education reforms. The education reforms in Japan started after the World War II. The 'six-three-three' grade structure was instituted and compulsory schooling was increased to nine years. The aims of Japan education were reflected in the Law of Education that defined the aim as "*the full development of personality, striving for the rearing of people, sound in mind and body, who shall love truth and justice, esteem the value of the individual, respect labor and have a deep sense of responsibility, and be imbued with an independent spirit, as builders of a peaceful state and society*." (MEXT, 2008)

Influenced by rapid development of science and technology in the 21st Century, the aims and contents relevant to science and technology had been added to or included in traditional aims and contents of other school subject in Japan (Ogawa, 2010). Thus, components of the aims of science teaching was scattered extensively across various categories of school activities. For instance in civic and social studies, one of the ethic course goals was to help students develop ethical viewpoints and ethical ways of thinking about the relationship between human and nature/ science and technology. However, communication among teacher subject was rarely happens. They also have little time and space for dealing with integrated learning. The integrated learning usually took the environmental education, global climate changed, and environment sustainable development. In fact, there was little consideration to STEM education. The lack of science teachers' interest in the contents of other subject, and the limited time for integrated learning, became one consideration of STEM education implementation in Japan. Because of STEM education implementation need collaboration and cooperation from other subjects. We found the small probability to implement STEM education into regular school systems. As MEXT did several methods to improve STEM education in Japan, STEM education implementation of specific school activities such as summer camp, was regarded as a proper method.

Preliminary research of STEM education and multiple intelligences profile in Japanese middle school was conducted to analyze science-learning processes. Physics subject was observed as part of the science learning in the middle school. The results showed that most of science learning were integrated to mathematics, while the technology (T) and engineering (E) couldn't be found during the observation. Moreover, most of trained intelligences were emphasized on logical-mathematical, visual spatial, bodily kinesthetic, and verbal-linguist intelligences that were triggered by teachers' question in stimulating students' inquiries. In general, the learning processes were divided into three phases; engage students' understanding, exploring the answers, and explaination the findings.

In order to engage students' understanding, the teachers started the lesson by delivering questions toward the presented phenomena. For instance, in free fall lesson, one teacher asked students whether or not they have the exact same fallen time. The question not only triggered students to think logically but also stimulated the creativity. "*Question to stimulated creativity must require and allowed multiple possible answers and demand actions"* (John Penick, 1996). Thus, through this question, the teacher asked students to do an action in the experiment. Moreover, logical mathematical intelligence could be trained through the activity and question that trigger students to reason effectively, to explore principles and cause-effect relationships, to classify, to understand complex relationships, to form ideas for predictions and questions (Gardner, 1989).

In order to explore the answers, students needed to collaborate their logical-mathematical, visual spatial and bodily-kinesthetic intelligences. This was one strategy in developing students' creative faculty that required exploring the full potential of all our intelligence and talent, not just the ones accorded the most prestige by society. This requires a constant awareness and utilization of all aspects of our beings. When the multiple intelligences are developed, it has a tendency to reinforce the performance of each other. The greater the number of outlets one can find in the expression, the more likely was one to find creative approaches to problem situations (Gardner, 1999). In order to explain the finding, students need to develop their verbal-linguist intelligence to communicate their thinking. This was one of 21st century skills that need to be developed to have a complex communication and social skills in processing and interpreting both verbal and nonverbal information from others to respond appropriately.

The impacts of learning processes to the multiple intelligences profiles were described in a significant difference profiles in one semester. The results indicated that students had different self-estimate of their intelligence at the end of semester. Most of them estimated their logical-mathematical and verbal linguist intelligence higher than before, but they put fewer estimates on bodily kinesthetic, visual spatial, and intrapersonal intelligences. It couldn't be neglected exterior influence of this result, for instance the other subjects that received in one semester.

Based on this preliminary research, it could be concluded that the integration of STEM was not applied yet in Japan. It needed further discussion and agreement among the teacher and schools in implementing STEM education. The strict regulation, curriculum, and teacher readiness did not support the STEM education implementation in schools for this moment. The implementation should be initiated by professional development toward STEM education. Thus, implementation of informal school activities was chosen as the strategy to introduce STEM education to students.

In 2013 and 2014, STEM education implementation was seen as trans-disciplinary program that invited an iterative cycle of engineering design Define-Develop-Optimize (D-D-O) that adapted from NGSS, 2013. The D-D-O approach was applied in booth activities that emphasized on engineering design. The characteristic of engineering design in the earliest grade was introduced students with 'problems'. Thus each booth activities proposed 'problems' and ask students to create the solutions. The impacts of camp activities, included the booth was analyzed from students' knowledge, creativity and multiple intelligences characteristics consistency. Students' knowledge was analyzed from mind maps and concept maps. Mind map analyzed students' knowledge and creativity of ideas toward tsunami problem solution, and concept maps were analyzed in terms of students' understanding of natural hazard disaster and STEM knowledge. The dominant intelligence grouping system took a part as the implication of students' intelligences diversities in attaining knowledge. The grouping system simplified the analysis on influences of multiple intelligences approach to the STEM education implementation.

Discussion of Students' Knowledge

Students' knowledge analyses were conducted in two different instruments referring to the programs evaluation that needs enhancement in the program

outputs. In 2013, the first frame of assessing student's knowledge through the concept map was faced difficulties or obstacles. Because of the students could not generate the concept understanding, most of the words were not clear concepts, but they put their own solution ideas. The arrangement of words did not fulfill concept map criteria that had four main assessment points; hierarchy, proposition, cross link, and examples. They grouped their sentence ideas without clear links, and link the sentences without propositions and arrows. Therefore, the students' works were viewed as a mind mapping result.

Logic and relevant ideas that generated in the mind map described the valid knowledge of the students, while the number of STEM related ideas indicated their understanding of STEM knowledge. In general, students' knowledge before and after camp activities was different, but not all differences were a positive increase (Group A = 57, B = 33, C = 69, D = 99, and E = -17). In this case, dominant multiple intelligences aspect could not give sufficient impact to the knowledge analyses. For instance, the A and B group students who were similarly dominated in logical mathematics couldn't generate much logical ideas as the C, D, and E group students who were dominated by music, naturalist and social intrapersonal intelligences. It was assumed that students' who were dominated in logical mathematical intelligence had a strong capacity to think with logic and have strong scientific reasoning. In fact, they produced a smaller number of STEM ideas than C, D, and E group. However, the A and B group students showed positive change in logic and relevant ideas after camp activities, while the C group students showed -0.38% decrease of logic idea, the D group students showed -13.2% decrease of relevant idea, and the E group students showed -1.57% decrease of relevant ideas.

Furthermore, understanding of integrated STEM knowledge could not be identified from their ideas, but it could be categorized into science, technology, engineering or mathematics related to context. For example, the A group student suggested ideas of 'make a pump which could absorb water in the sea and decrease the water of the sea', it was categorized related to technology context because it was refer to 'produce' something to help or fulfill human needs or wants. They also generated other ideas that was categorized related to science contexts such as 'give a bigger shock than earthquake', 'drop satellite to tsunami' (even though it was not-logic), 'attach the plate to the other', and so on. The ideas that related into engineering contexts were identified from word 'built', such as

‘built shelter'. ‘built DAM’, and so on. In general, numbers of science related contexts ideas were achieved the highest numbers among other STEM disciplines, and engineering related context ideas number were greater than technology and mathematics, but the D and E group students generated more technology related context idea than engineering.

The increase of all students’ knowledge before and after camp activities was not significantly different, but the range of difference (99 – (-17)) was considerable. For example the A group students who were dominant in logical mathematical and visual spatial increased the logic ideas for 8.97%, the B group who were dominant in logical mathematical and body kinesthetic increased the logic ideas for 6.49%, and the D group who were dominant in naturalist intelligence increase into 16.93%.

The impacts of booth activities into students’ knowledge described from several ideas that related to the booth activities. In general, ideas were linked with pumpkin launcher, roller coaster, robot, diapers, watercraft, and suisin-kutsu. Nonetheless, analytically, ideas were belonging to non-logical idea. For instance students suggest making giant pumpkin launcher to move people from the tsunami to be placed on the hill. Thus, we assumed that the theme of booth activities should be related to the proposed problem in camp.

In 2014, students’ knowledge was measured from the concept map. Reflected from last year, the strategies of instructions were changed. Concept map-making processes were initiated by a puzzle game that could stimulate their verbal linguist intelligences to find the words related to natural hazard disaster concept. Students’ understanding of natural hazard disaster and STEM related knowledge was varied. The understanding of natural hazard disaster was described from the proposition, hierarchy, cross-link and example in the concept map. Moreover, the STEM related knowledge was described from their ideas of solution for the hazard. The concept map was scored using a rubric that adapted from Novak (1984). He viewed that concept map not only measured students knowledge understanding but also the creative thinking from a good hierarchy and cross-link.

Better than last year, the influence of dominant intelligence into students’ knowledge understanding could be analyzed clearer. It described differences score analyses, the C group students who were dominated in logical mathematical intelligences got the highest natural hazard disaster knowledge understanding score (123) among others group, but they presented the lowest differences score

of STEM related knowledge (20). Moreover, they were the only group who could correlate one sub concept to another sub-concept; therefor they got the highest cross-link score (10). The A group students who were dominated in musical rhythmic intelligences achieved higher differences score (31) than the B group students who were dominated in bodily kinesthetic intelligences. Even though the B group students produced many words in the concept map, they didn't achieve the highest differences score (28); they also didn't achieve the cross-link score (0). Furthermore, C group students achieved the highest difference score in grouping system (74). The grouping system described the valid understanding of the concept. Thus, it could be concluded that the C group students who were dominated in logical mathematical intelligence had more effort on understanding the natural hazard disaster than others. This fact showed consistency of MI characteristic theoretically with the reality. However, they didn't produce much STEM related knowledge words.

The impacts of booth activities to students' knowledge also described from several solution ideas that link to one concept that they learn from booth activity. For instance, Cgroup students who learn about 'fire' in the first session booth activities wrote the solution ideas that derived from 'fire' concept. It showed from the ideas of making 'building', 'diagonal brace', and 'sematic breaker' that were linked to the 'fire' concept. The concept of lava layer was given in volcano booth that first delivered to the A group students, and the solution idea that related to the lava layer concept was generated by only this group. Furthermore, the B Group students who were dominated in bodily kinesthetic and were attended the tsunami booth in the first session, generated most of related to tsunami problem ideas. And the D group students who attended nuclear radiation booth were generated ideas that related to the nuclear power plant. These facts showed that their knowledge was influenced by previous experiment in the booth activities and most of their ideas were more logical and relevant to natural hazard disaster.

Reflecting from the results, the instruction strategies in delivering concept map assessment should be initiated by some guidance in understanding and practicing the concept map-making processes. Especially, for the beginner who were never be trained to make a concept map. Other researchers (Diane C. Raise et.al, 1998) had begun the study by implementing *concept map training phase* and *concept map data collection phase*. The results showed valid, useful, equitable, and reasonably reliable information about students learning in real world of life

science class. Therefore, initiation phase in conducting concept map-based instruction should be applied in further research. This study suggested that a concept map might be used in assessing declarative and procedural knowledge in science classroom.

<u>Discussion of Creativity Skills</u>

There were several suggestions for developing creativity skills. Teachers who were amenable to change and who model divergent thinking themselves seem the most effective in stimulating creativity in students (Karnes et al., 1961). Besides using individual assignments to stimulate creativity skills, teachers should provide situations for students to participate in-group activities (Davis, 1991; Davis & Rimm, 1985). These group activities, in addition to enhancing creative thinking skills and academic performance, should provide students with opportunities for promoting peer acceptance (Karnes et al., 1961). Another technique for improving creativity skills was the inquiry–discovery or problem-solving approach, which was an indirect teaching method (Feldhusen & Treffinger, 1980: Daniel. F. Jr., 2001). Treffinger (1980) suggested that creativity was related to the discovery processes. They stated "*experience with discovery learning enhanced creative performance by forcing the learner to manipulate the environment and produced new ideas*" (p. 34).

One important way to obtain information about people's creativity was through their actual behavior—their creative products, performances, or accomplishments. There were two general ways to obtain these kinds of data: through records or first-hand observations in natural ("real-life") settings, or through the person's performance in constructed tasks that simulated or approximated the real-life settings but could be arranged and observed under controlled conditions. It might be useful to think of the former set as documentation of real-life creativity and the latter as a demonstration of creativity under realistic or simulated conditions. Moreover, self-reported data were also possible to obtain information about people's creativity from the responses they provided to questions about themselves and their behavior. The other approach was rating scale that be done by teachers, parents, mentors or other adults. The last one was the best that collects persons' response toward structured questions or task.

In this research, students' creativity skills were analyzed from different

sources type. In 2013, it was analyzed from students' ideas on mind mapping, while in 2014 it was analyzed from solution designs and students' profiles. The decision was influenced by the validity and reliability of students work results. In 2013, solution ideas could give clear information about students' creative thinking in generating the ideas. In 2014, most of concept map results cannot measure valid creativity because most of the students did not make cross-link between sub concept which was the important criteria to judge students' creativity (Novak, 1984).

Generally, students' creativity skills after camp activities were better than before camp activities. In 2013, creativity skills information was gained from the actual product of a mind map that described the increase. It concluded that the entire groups increased positively even though the increase was less than 0.854. The highest score difference of creativity skills was achieved by D group students (0.854) who were dominated in naturalist intelligence. It was noted that D group students did much effort to increase their creativity skills. On the other hand, group A and B who were dominated in logical mathematical did not showed much differences score (A = 0.097, B = 0.543). They showed higher creativity score than other since the beginning, thus their effort to increase creativity skills was not as much as D group students.

In order to get more valid information of creativity skills, the assessment method was added in 2014. It was not only from actual creative product but also from the test. The TTCT tests gave information of students' creativity skills that can be analyzed statistically. It showed that creativity skills increased significantly after camp activities. Moreover, the actual creativity product of solution design in each group showed that the C group students who were dominated in logical mathematical intelligences achieved the highest score of creativity skills. They were fluent in designing more than two flexible ideas of the solution by reviewing all aspects of hazard impact: object, building, structure, and tools. However, it was found that almost all students get the similar idea in one group. Thus, the originality was low. For instance, all of the D group students generated turbine energy ideas, and then in this case the creativity was measured from variety type of turbine design.

However, the impacts of dominated multiple intelligences in both camp activities couldn't be identified statistically. Similar ideas in one group and varied instruction that delivered by the tutor of each group influenced the diversities

characteristics. There was little evidence that showed the influence of dominant multiple intelligences to the ideas. There was no significant different of creativity skills for each group that showed from Kruskal Wallis statistic analyses result where H_{ob} = -3.37 that was not exceeded χ^2= 7.815. These fact supported Getzels and Jackson (1962) and Torrance (1962) study that viewed intelligence and creativity are independent, and Ferrando, M.1, Prieto, M.D, Ferrándiz, C, and Sánchez, C. (2005) study that indicated low relationships between creativity and intelligence.

Based on the result in both STEM education implementations, it was found that creativity skills should be assessed using more than one method to improve the validity and consistency of results. Moreover, the uniform instruction and guidance to all students were needed in order to corroborate significant differences, thus the relationship between creativity and intelligences could be study in advance.

Discussion of Multiple Intelligences Characteristic

Definition of intelligence was changed. In the past, intelligence was fixed, unitary, measured by scored number and in isolation, and it used to sort students and predict their success. Recently, intelligence could be developed and exhibited in many ways (Multiple Intelligence); it was not numerically quantifiable and was exhibited during a performance or problem-solving processes. It was measured in context/real-life situation, and it used to understand human capacities and the many and varied ways students could achieve or perform (Silver, Strong & Perini, 2000). Thus the students and teacher could be more adapted into all seven intelligences. It was noted that each person had a unique profiles of intelligences that might be strong in one or two intelligences. In order to improve the consistency of the multiple intelligence theory, there should be better if we conducted more than one assessment of intelligences. It could be measured by self-report data (MI profile) and rating scale assessment (MI characteristic observation).

In 2013, the consistency of multiple intelligence profile and those characteristics did not show satisfying results. Some of students with the same dominated intelligences could not present a strong characteristic that relevant to their dominant intelligences. Some obstacles in rating scale process impacted it.

For instance, musical rhythmic and naturalist intelligence characteristic could not be observed in these camp activities. There need more activities that could help the observer identify students characteristics, thus rating scale process of MI characteristics should be supported by relevant activities that stimulated students to use their related intelligence in solving the problem, so that the observer could find the characteristics.

In 2014, all STEM camp activities were linked to the multiple intelligences approaches. The activities were developed not only to improve STEM knowledge but also to develop the multiple intelligences. Every activity at least characterized one or two intelligences so that the rating scale process could be made in smaller obstacles. Furthermore, grouping system and the MI measurement instrument influenced the consistency of multiple intelligences characteristic profile and students' knowledge. The MI instrument of 'How Many Intelligences Are you dominant' that was adapted from Laura Candler (2011) was a self-report assessment that asked the student to answer whether or not they were in the same situation as the statement of intelligence characteristic. Using this instrument, student scored by '0' or '1', and the number of statements for each intelligence area was not enough to get valid justification of students' dominant intelligences. Thus one student had more than one dominate intelligence area. On the other hand, the MI Quiz instrument that developed by ITC resulted more valid justification, because students estimated "1" to "5" their intelligences score for each statement. It made one student had one dominate intelligence. Thus, the consistencies results were better than last year activity. The consistencies results were showed by positive R- value of MI profile and these characteristics.

Built on the fact above, multiple intelligences characteristics could be simply identified through related activities that stimulated students to use the intelligences. However, the short activities cannot change students multiple intelligences profile significantly. It was described from a statistical test that showed no significant differences of MI profile before and after camp activities. There was little change in students' attitude in estimating their intelligences because the developing process of intelligences need more time. It supported the preliminary research of MI profile in Japan and Indonesia, where the students' MI profiles changed significantly after one semester.

The Impact of STEM Camp Activities to Student's attitude of STEM Interests, Agreements, and Perspectives

Both of STEM education implementation in the camp activities had purpose to improve students' interests, and knowledge in STEM discipline. The first implementation was more emphasized on STEM education introduction to students, parents, teachers, and other community. The impacts of this implementation could be seen from students' enthusiasm in joining the camp; moreover some of them have participated again in the next camp. Almost 50% participants in camp 2014 were part of 2013 participants. In 2014, the camp activities had purposes to increase students' interests in STEM field careers, to increase students' 21st century skills (creativity skills, non-routine problem solving skills, complex communication skills), to provide learning environment that considering their dominant intelligences, and to investigate consistency of MI characteristics with their dominant MI profile.

In order to collect valid data on students' attitude toward STEM education implementation in 2014, they were asked to fill in the questionnaire related to interest, agreement and perspective of STEM.

In the beginning of camp activity, the results described that 90.8% students were interest most in science, 72.06% students most like science for their careers, 77.78% most of their family interests in technology, 77.63% their family most supported them to science, and it was impacted in their 93.43 % degree choices in science. In this case, it seemed that students were less interested in math and engineering. Therefore, engineering learning approach needed an improvement. Furthermore, 54.8% students agreed that a career in science would enable them to work with other in meaningful way, 53.9% agreed scientist made a meaningful difference in the world, 66.96% students agreed that having a career in science would be challenging. The lowest percentage of agreement was described in the statement that 'solving disaster problem was difficult'. Only 30% of students agreed with this statement, on the other word, 70% of them disagreed that 'solving disaster problem was difficult', they thought it was not hard to solve disaster problems, however after camp, the number of percentage who were agreed with the statement was increase to 34.17%, that mean some students changed their attitude and feel that solving disaster problem was hard, even though statistically it was not different significantly.

In the STEM content, initially they perceived that STEM contents were less familiar, complicated, hard, slow in development and less beneficial. After camp, they thought it was lesser familiar, complicated, hard, slow in development and lesser beneficial. However, they thought STEM contents were more strong, expanding, good, necessary, understandable, active, interesting, mean a lot, and appealing after camp activities. In general, these perspectives were different significantly before and after camp activities.

The increase of students' interests into STEM through camp activities implementation also showed by CONNECT partnership (2008-2010) study that offers five days camps of 'sustainable environment' and 'biotechnology and forensic'. The results showed that the number of students who stated that they viewed science as "fun" increased after both 2009 camps, from 45% to 66% after the sustainability camp and from 61% to 72% after the forensics camp. At all four camps, students' self-assessment of scientific knowledge about the camp topic increased greatly after participation. Moreover, parent's survey had a 20% response rate. Most parents (88%) stated they felt their child had learned to "A Lot" at camp. The remaining 12% of parents indicated their child had learned "something" from camp. All (100%) parents agreed with statements that participating in the camp had increased their child's interests in science (UMass Donahue Institutes, 2011).

Based on the results, mathematics, technology and engineering integration should be improved in order to increase students' interest into STEM field and careers. Furthermore, more familiar, simpler, and more beneficial content would help students in understanding and perceiving STEM better. Parents' responses and suggestions of camp activities would also improve the implementation results. Thus it should be applied in the further implementation.

STEM Education Implementation in Indonesia

Similar to the trigger of STEM education implementation in Japan, the demand of the 21st Century stimulated the STEM education implementation in Indonesia. The general purpose of the implementation was to find the appropriate implementation method of the new released 2013 national curriculum. That was a completion of the previous curriculum adjusted for 21st century demand. The

specific goals of the implementation were to improve STEM interest and knowledge in order to enhance 21st century skills.

Different from implementation method in Japan; the implementation in Indonesia was conducted by the formal sector. It was forced by the newly released national curriculum that asked schools to use the curriculum. Therefore, schools were trying to find appropriate methods to implement the curriculum.

The most specific changed in this curriculum was the thematic contents that confusing for the teachers. The thematic contents seemed proper to the integration processes of STEM education that needed the general theme. Thus, school welcomed the STEM education implementation to give teachers experiences and understanding of STEM education.

Discussion of Teacher Training Results In Indonesia

The first implementation that initiated by teacher training described teachers perspectives of STEM integration to the new released 2013 national curriculum compare to the previous one, KTSP. The results showed different perceptions of STEM integration into curriculum. The fourth grade teachers suggested that STEM was represented in 4^{th} grade because of the thematic concepts in 2013 curriculum, so that it could be coordinated well among subjects. They hope fourth grade students could master “high order thinking” skills to solve problems and to improve their communication skill in describing ideas. On the other hand, 5^{th} and 6^{th} grade teachers suggested that STEM was representative for certain subject matter in KTSP curriculum, but they believed that STEM activities in certain matter will engage students in class. Moreover they argued that curriculum, learning methods, teachers’ capacity, and students’ discipline should be changed in order to improve STEM education.

Some teachers faced difficulties in integrating STEM to the curriculum contents. They were new in teaching science and they just involved in this school for one year and teach non-science lesson. Nevertheless, most of them viewed STEM as integrated disciplines through overlapping and sequencing by complemented, connected and correlated each discipline. Unclear examples that were given by first and second grade teachers illustrated the obstacle in integration planning processes. Thus, additional integrated STEM resources were needed to provide specific example for teachers.

The impacts of teachers training to the STEM integration perceptions that

measured by STEM Semantic Survey (SSS) and Likert-scale questionnaire showed that most of their perceptions toward science, engineering, mathematic, STEM career, and STEM integration was changed significantly, except perceptions toward the technology. In contexts of Japanese teacher training, the results of significant differences were showed only in STEM integration. It indicated that the short socialization activities were not enough to change teachers' perceptions of science, mathematics, technology, engineering, and STEM career significantly.

The Likert type items questionnaire identified teachers' responses related to their interests, perceptions, and STEM training reflection. Likert type item was item identified as a single question that uses some aspects of the original Likert response alternative (Clason & Domody: Boone, 2013). The items collected data in ordinal score, so that the analyses processes took descriptive statistic method. This questionnaire took at the end of teacher training program that consisted STEM explanation and hands on activities to develop teacher curiosity and creativity. All teachers strongly agreed that they eager to implement STEM education in class.75% strongly agreed that STEM could develop student activity, and 31.25% teacher strongly agreed STEM were important knowledge that could help students facing the 21st Century. Furthermore, 56.25% teacher perceived applying STEM education was not impossible to do, 56.3% agreed that STEM education could be applied at any level, and 87.5% disagreed that STEM integration was hard to do in class. Related to STEM integration, 62.5% gave positive respond that to integrate science with mathematic was easier than with technology. Toward the teachers training, 100% teacher gave positive feedback that STEM education training should be done periodically, they also agreed that deep understanding of science and mathematic knowledge were needed to implement STEM education, and agreed that cooperation among science collogues would make STEM implementation easier.

The other impacts of teacher training were described from self-reflective results toward the training activities. Self-reflective showed their awareness to the teacher training activities by rethinking 'what did they learn' that measured their understanding of STEM activity, 'what problems did they faced' that measured their skill in defining problem, and 'how to solved problem' that measured their problems solving skill. *The understanding* was measured the statements that were described with specific details and examples and comparisons how the

understanding had been changed; *the define problem skill* measured how they identified the key element of the problem and clearly outlined the objectives; and *the problem solving skill* measured how they develop excellent strategies that were insightful and used logical reasoning to reach accurate result.

In the first STEM activity (DCT-1), the teachers were asked to create balloon-powered car with provided materials. They stimulated to think creative and innovative in designing and constructing the car. Most of teachers stated that they learnt to make balloon-powered car without details explanation and examples and comparison that showed how understanding has changed, thus their average score in understanding domain were low (1.24 at range 0-4 score). Furthermore, they stated that most of problems that faced in the activity was the limited materials so that they had to think how to design the innovative and creative car. In fact, some of them missed to identified the key element of problems (such as wheels size, and balloon position) and did not clearly outline the objective (what was the impact of the wheel size and balloon position), thus they were scored 2.06 in average. In solving problem, most of them assumed that the balloon position should be in the car backside, moreover the wheels and car body should have the same balanced, but most of them were failed to develop excellent strategies and to use logical reasoning, thus they were scored 1.65 in average.

In the second STEM activity (reverse engineering), the teachers were asked to explore the work of kid toys and recreated the different designs of the toys. The understanding of STEM activity better than the previous one, some of them stated the understanding changed clearly, thus they were scored 1.59 in average. There were three types of explored toys; robot, car, and gun toys. In defining the problem, most of teachers who explored the robot stated that they faced difficulty in identifying the robot work because they were unfamiliar with the component name and function at the machine; and some of teachers who explored car and gun stated that they faced difficulties in redesign the simpler car and gun, they also unfamiliar with the components and theirs work, thus they were scored 2.47 in average. In solving the problem, most of them realized that they had to learn more about STEM by discussing and browsing the information; and some of them developed a strategy by disassembled the toy and identified the work of each component, thus they were scored 2.06 in average better than previous activity.

In the third STEM activity (DCT-2), the teachers were asked to create paper-bridge with minimum sheets number of newspaper. Most of them stated

that they learnt to make paper-bridge without additional explanation and details, thus they were scored 1.24 lower than reverse engineering activity. In defining the problems, most of them faced difficulties in design the bridge that could hold the determined weight; some of them stated that it was hard to roll up much newspaper, they also did not identified the key element of the problem, thus they were scored 1.59 lower than reverse engineering activity. In solving problems, some teachers stated that rolled up the paper slowly and neatly to dismiss the hole inside as a good strategy, some of them stated that the rolled up paper should be glued by tip to strengthen the bridge as a strategy, thus they were scored 1.98 better than DCT-1 but lower than reverse engineering activity.

In summary, the result showed that there were significant differences of defining problems and problems solving skills. But there was no significant difference in understanding the STEM activities.

Overall, these study results supported Berlin & White (2010) study that conducted a unique integrated teacher education program in integrating mathematics, science and technology, which showed teachers' perception changed before and after the program, and suggested the integrative activities. Thematic unit in both curriculums that applied in school sample was appropriate to be applied in class since it uses single class teacher systems. It supported the STEM integration, because integration was generally used in a single teacher class system where teacher taught all subject in curriculum (Dilek, D, 2002). However, the integrations faced challenges in a long history (Pannabecker, J. R, 2002). He concluded that physical, conceptual, social, and political values have influenced the integration of technology with math and science in the past.

Discussion of STEM Implementation in Learning Process

The class implementation was selected from the decided topic that appropriate to integrate STEM education. In elementary level, the fifth grade teacher proposed subject theme 'friction', while in secondary level the first grade teacher proposed subject theme 'motion'. Both of sample used KTSP curriculum as guide of learning goals. The class sample that used 2013 curriculum couldn't be taken at that moment because of the readiness of human resources. Most of teachers who used 2013 curriculum were 1st until 4th grade teacher, but the participant who most of their education backgrounds were not in science lacked of

their confidence. Lacked of coordination among teachers in those grades also became a consideration of class implementation.

The standard competence in ‘friction’ lesson was to understand force, motion, energy, and its function. The indicator of learning was to compare object friction in certain surface condition. And the learning purpose was students could compare object friction in certain surface condition. The materials that provided in this lesson were marbles, board, hard paper, cloth, sandy paper, and play-dough. Teacher asked students to do experiment using those materials to find out what was the certainty of the result. In general, the lesson integrated more science and mathematics. The technology was integrated in the explanation, while the engineering processes was not integrated. The learning processes were not totally integrated T and E, and did not using STEM context, thus it became a big challenge for further implementation. At the discussion before implementation, seemed we were agreed that the theme of friction will be delivered by asking students to create roller coaster with different surface condition, but some obstacles in preparing the materials cancelled the plan. Therefore, the interview results were not satisfying, some students responded that they didn’t understand some parts of lesson, but most of them could concluded that the movement of marbles were different affected by the surface conditions.

The ‘motion’ lesson was conducted better than ‘friction’ lesson. The teacher integrated STEM in order to make student understand the characteristics of linear motion. Teacher asked students to create a balloon-powered car and to analyze the motion. The engineering design was imbedded in the lesson during making-car processes; the mathematical process was imbedded when they calculated the time and displacements of car movement, the simple technology use in car materials, and science was imbedded in whole learning process. However, some of students confused of linear motion concept because some of their data did not show those characteristics. It found that not all group could finish the task completely, they spent long time in creating and testing the car and the data number did not enough to be analyzed. Moreover, students questioned the making-car procedures to teacher for several times, it indicated students’ reading skill need improvement.

Based on the class implementation results, it should be consider the proper lesson plan that integrated whole STEM in the learning process by embedding T and E and choosing appropriate theme that could integrate STEM. Time

consuming also should be predicted well in order to achieve the learning goals to create competence students.

In order to study the impact of multiple intelligences into STEM education implementation, the second implementation was designed using multiple intelligences approach. The challenge in this implementation was integrate STEM in biology subject in theme of 'living things classification', students were grouped based on their dominant intelligences and asked to identify the differences of human and other living things in the school neighborhood. In this learning process, technology of personal computer was used to browse the information. Students gave freedom to find the information.

Overall, this lesson did not use STEM context, and did not integrate mathematics and engineering. However, students' motivation in learning processes improved well. These facts was supported by other researchers that admitted the STEM integration into biology subject was challenging, most of research took a correlating approach in integrating engineering into biology subject. For example the technological contribution of engineering field of biochemistry research that conducted by Susan. E, Riechet, Brian. K (2010), she correlated robot works to kinematic configuration of stick insect. This study was conducted for high school students, thus couldn't be applied in secondary level. Therefore, the impacts of STEM education learning to students' achievement was no different significantly compare to the students' achievement in traditional classes. Moreover, the STEM education using multiple intelligences approach was not statistically significant difference to the STEM education learning without multiple intelligences. However, the range gain different was considerable.

From the result, it showed that STEM education implementation in learning processes need improvement, especially in the integration of T and E and the using of STEM context. The deep understanding of STEM content would help in designing better lesson plan in the future. Thus in the further semester the implementation strategy was changed into PBL approach at informal learning environment. The results showed that the students' creativity skill could be stimulated through STEM project activities. It was described from their project results that students developed creative and innovative ideas by the influence of STEM activities.

CHALLENGES COMPARISON OF STEM EDUCATION IMPLEMENTATION IN JAPAN AND INDONESIA

The Challenge in Implementing Technology (T) and Engineering (E)

Based on the whole result study, the implementation of STEM education in two different methods met the same challenges in implementing technology and engineering. At informal lesson in Japan, the challenge arouse in designing the booth activity that should be integrated the T and E and related to the camp theme, while at formal method in Indonesia, the challenges arouse in implementing T and E into learning process. The comparisons of the challenges were evaluated seven elements; integration of science and math, technology, engineering design, STEM professional, link to career, what students do, and autonomy. The evaluation result divided into four categories: non-STEM, emerging, implementing, and exemplary. The rubrics detailed were showed in appendix D.

a. Integration of Science and Mathematics

In 2013, some of booth activities were less related to the *tsunami* theme in camp activities, thus some of students' solution idea were not logic and relevant to the *tsunami*. Most of students generated ideas that reflect from the gained knowledge in booth activities. Furthermore, the other STEM researcher evaluated the camp activities were in emerging category for the integration of science and mathematics. It was focused on only one primary subject areas (math or science) with the connection of math or science. For example, the diapers booth that gave knowledge of how the diapers works in absorbing water by the polymer inside it. All of activity in diaper booth was emphasized in science; the technology term was defined as the explained product; and the engineering design was not applicable here, because the booth showed the basic science concept of diapers work and did not ask student to design new diaper. However, the 'pumpkin launcher' and 'roller coaster' booth were used some portion of engineering design in guiding students to solve the problem.

In 2014 camp activities, the integration of science and mathematic implementation was in 'implementing' category. Most of the booth and design solution activity were focus on one primary subject area with strong connection to mathematics or science, and all of them were related to natural hazard disaster (volcano, tsunami, nuclear radiation, and fire). For example, the volcano booth

activity gave knowledge of volcano eruption process and gave experience to predict and measure the area of lava pathway. It improved the students' knowledge of science and mathematics skills.

At the class implementation in Indonesia, the integration of science and mathematics were in "emerging" category; the learning processes were focused on only in science with the connection of mathematics. Most of teachers faced difficulty in finding coherency of standard competences in curriculum in term of STEM education. Thus, the learning was focused in science and related to the technology. For the elementary level, the standard of science are to know, to address, and to appreciate science and technology; and to embed critical, creative, and independent scientific thinking and attitude. And for secondary school the standard are to get basic competence of science and technology: and to develop scientific thinking in critic, creative and independent way. The standard competences that were chosen in elementary level are 'to describe the relationship of force, motion, and energy (gravity, friction, and magnetism)'. The learning processes were fulfill the standard competencies, but were not fulfill the science standard itself because of the lack of technology integration.

b. Technology used in lessons

In 2013 camp activities, the technologies were used as trial to research fact and for presentations. Technologies were referring to the products that explained in the booths, not the products that produced by students. Thus, the technology implementation was belonging to "emerging" category.

In 2014 camp activities, the technology implementation was also in the 'implementing' category. It was used to collect and record data. For example, the radiation booth activity used 'cloud chamber' to analyze the atomic radiation processes. However, in the context of learning, most of the booth stimulated students to create technology in solving the problem. For instance, the volcano booth activity stimulated students to make a seismograph, the tsunami booth activity triggered students to create strong levee, the fire booth triggered them to create the seismic breaker, and the radiation booth triggered them to create windmill.

In Indonesia, the first technology implementations through formal learning processes were in non-STEM category. The technology only use for presentation,

but in the second implementation it was used to collect data. However, at informal learning processes, it was in implementing category where it used to collect and record data and it is used in the similar manner as STEM professional. For example, the alarm was used to create the flood detector, and the pump used to take up the water in distillation processes.

c. Engineering Design

In 2013, the engineering design implementation was in “emerging” category. Some portions of engineering design D-D-O were used to guide the processes of problem-based learning (PBL). Not all booths applied the engineering design, but the other used it partly, for example the ‘chair’, ‘pumpkin launcher’ and ‘roller coaster’ booth activities.

In 2014, the engineering design D-D-O was used to guide the processes of problem-based learning (PBL) with some loose interpretation of each step. It was evaluated as “implementing” category. Almost all booth activity trigger students to make solution design of the problems, but there still some misinterpretation in ‘develop (D)’ step. For example, in the total design processes, students were guided by several questions to develop sustainable environment in the future that could survive from hazard disaster, the results showed that some group of students designed the solution by considering one subject problem of natural hazard disaster only, such as designed the windmill only as a energy alternative solution rather than nuclear plant without implementing other solution for other hazard disaster. The most complete design solutions were made by the C group students who were dominated in logical mathematical intelligences that could design a complete sustainable environment toward hazard protection designs that was not only design structure but also building, object, and tools (see appendix E, the students design).

In Indonesia, some of formal learning process was used some portion of engineering design to guide the processes of problem-based learning, thus it was in ‘emerging’ category. For example, in secondary level students were asked to design balloon-powered car that can fulfill the characteristic of linear motion. During this process of designing the car, the engineering design was applied. However, the implementation at informal lesson was better than at formal learning, it was in ‘exemplary’ category. It used to guide the process of project-based

learning (PBL) with full integrity of each step, and students collaborated during the processes toward the best solution.

d. STEM Area Professionals

In 2013 camp activity, the STEM area professionals are mentors for the problem based learning (PBL) processes, the first mentor were biology scientist that taught students to dissect frog, and the second mentor gave PBL related to robotic using wood material, stimulated students to create a robot which could move in linear motion by considering the balance of leg shape. Therefore the STEM area professionals' implementation was in 'implementing' category.

In 2014 camp activity, the STEM area professional was invited from nuclear radiation field. He explains the safety of nuclear plant and how deals with radiation. He is not STEM professional, but he works in STEM area professional, thus the implementation was in 'emerging' category.

In Indonesia, the STEM area professionals did not conduct the learning process, thus it was in non-STEM category. The teachers who taught had science educational background but they were the beginner in teaching science using STEM. However, they had followed the STEM teacher training and had better understanding of STEM than other. Therefore the professional development was needed to improve the STEM education implementation.

e. Link to Career

During 2013 camp activity, the STEM area professionals who introduced and explain STEM related knowledge through hand on activities, gave the description of how scientist works in their career to students indirectly. However, in the context of booth activities, the career issues was mentioned but not embedded in PBL processes. Thus, the implementation of link-to career was in 'emerging' category.

In 2014 camp activity, the implementation of link-to career was in 'emerging' category. It was mentioned but not embedded in the PBL process. For example, in volcanoes booth activity students indirectly were modeled as the geophysics that want to know the lava layer, and they were asked to figure out the technique of finding the lava layer. The impact of camp activities to the career interest showed that there was not significant different of career interest after camp activity. Thus, the 'link-to career' implementation needs improvement.

In Indonesia, the 'link-to career' was not integrated in learning; it was set-aside for 'career week' in school annually event. The students interest toward STEM career seem very low, it described from number of students who were interested in joining the STEM Project Based Learning in the afterschool activity. Thus the 'link-to career' implementation should be improved in order to increase the interests.

STEM researchers suggested that the early interests in science and engineering were a better indicator of whether students would pursue in that field. Therefore 'link-to career' implementation should be applied better in order to improve the STEM career interests. The example of implementation was the *Operation SMART* that is a national program offered by Girls Inc. and provides K-12 participants an opportunity to explore STEM careers through afterschool and summer programs. Students spent time working on science experiments, designing projects and having discussions about careers in STEM with professional mentors. The results showed that number of participants who say yes to the statement '*not having science will be okay with me*' decreased from 40% to 3% after they joined the program (Afterschool alliance, 2011).

f. What were students doing?

In 2013 and 2014 camp activity, most of students were triggered to work together to solve the problem; some students were identifying parameters and obstacles through discussions; students were communicating solution; and some students were applying content to identify the parameters and obstacles. It was recorded in all camp activities and described on the group work results such as mind map, concept map, the design solution, and the prototype that showed their collective prediction and assumption of problems that arouse in tsunami and natural hazard disasters issues. Therefore, the implementation category is 'exemplary'.

In Indonesia, the implementations category were 'implementing', the students enjoy learning the new method of teaching, even though it still emphasized on science with less integration of mathematics, technology, and engineering. They were working together to solve a problem, and identifying parameters and obstacles through discussion, but only some of them who communicating solution and applying content to identify parameters and obstacle.

Therefore improving hands-on activity and encourage more scientific discourse are important in improving STEM education.

g. Autonomy

Autonomy is opportunity to express ideas. Haiyan Wang (2014) viewed learner autonomy as a new realm of learning that defined as learners' ability of managing their own study, including setting learning objectives, self-monitoring, and self-evaluation (H, Holec, 1981: Haiyan, W, 2014). In this study, it defined as students' ability to managing their own ideas in solving problem, including setting the ideas relation to the problems.

In 2013 camp activities, students had autonomy to express their ideas in problem based learning processes at booth activity and design solution with much guidance from mentor. Therefore, this implementation category was 'emerging'.

In 2014 camp activity, this implementation was in 'implementing' category. The students have more autonomy to express their idea at design solution with less guidance from mentors. They generated and discussed ideas based on their own thinking that influenced by their experience in the booth.

In Indonesia, students have autonomy to express their ideas in problem based learning with much guidance from teacher. For example, secondary students faced difficulties in understanding the instruction of making balloon-powered car, thus the teacher many times explained the instruction. Therefore, teacher should implement specific strategies to counter deficiencies in reading levels, context and vocabulary.

Using STEM Contexts

Applying STEM related issues into the STEM program were the most significant challenges in the implementation processes. Addressing this challenges require an educational approach that embedded the real-life situations and global issues at the central position and uses the four disciplines of STEM to understand and address the problems. In order to evaluate the programs, Bybee (2013) suggested 4 Ps: What is the purpose? What policies will support STEM education? What programs are needed to implement STEM education? And what practices are most appropriate for STEM education?

The main purpose of STEM education implementation in Japan and Indonesia is making students to be STEM literate as an effective citizen in 21st century. There is not specific policy at this moment such as STEM standard that supported the implementation in both countries. Therefore, the implementations are doing in limited scope of samples. However, the science standard and curriculum in Japan

considers the implementation of technology and science at all subjects, and to support these goals, MEXT provides research fund to improve the implementation. In Indonesia, the technology and science implementation be considered only in science subject standards, but the new curriculum policy design thematic content that merge all subject standard competences in one theme so that STEM integration is applicable.

The policies gave adequate supports in the STEM education implementation. The programs were included the materials that needed in practices. And it was different in both implementation, but generally it used easy to get and simple materials. The practices themself were used different approaches; camp activities approaches in Japan and learning implementation in Indonesia.

The evaluation considered three phase purposes, program and practices in several elements such as time, participant, location, product, problem, and agreement.

a. Purpose

The main goal of these programs were related to STEM education purposes that emphasized on the first purpose of STEM education: ‘to improve knowledge, attitude, skills of identifying questions and problems in life situation, to explain the natural and design world and to draw evidence-based confusion about STEM related issues’. The ‘purpose’ evaluation consisted of three dimensions, such as establishing goals for STEM activities, establishing priorities for STEM goals in the STEM activities, and providing justification for STEM education.

Based on that elements, the establishing goals for camp activities in 2013 took more than one week, the participants who involve in this process were the faculty colleagues. The preparations of planning (establishing goals, priorities, and providing justification) were conducted in university that easy to be accessed. The problems in establishing purposes of this program were considered in the risk to students, the cost to the program conductor, the responsibility of participants, and the benefit for students. Based on the consideration, the major problem arose in designing the less risk theme of camp activity for students to fulfill the goals of improving STEM knowledge and interest. Finally without taking long time of achieving agreement among participant, *a tsunami issue was* chosen as a theme that could integrate STEM discipline in understanding the issues that take less risk

for students. However, the conductor participants take more responsibility and it took more cost.

In 2014 camp activities, the major problem arose in designing better 'less risk' theme of camp activity by reflected to the previous camp activity. Goals of this camp were enlarged, not only to increase STEM knowledge and interests, but also the creativity skills. Finally with fair quality of communication among the participants and longer time discussion among conductor participants, we created natural hazard disaster that included tsunami, volcanoes, fire, and nuclear radiation as a theme that can integrate STEM disciplines in understanding the issues that takes less risk for students.

In Indonesia, the major problems were in deciding the school sample curriculum coherency to STEM education, the teachers' capacity, and the students' knowledge. The risk of STEM implementation to the teachers was prepare new model of teaching science to fulfill the purpose of STEM education. Before creating new teaching model, they should analyze the probability of STEM integration into curriculum. Therefore based on evaluation, the lack of resource and STEM professional should be minimizing through a professional development program.

b. Program

In 2013 camp activities, developing materials and adopting a STEM program for STEM was conducted using more than one month. Faculty colleagues in university did it, and they produce problem based learning instruction that fair related to civic phenomena. The problem in this step was the lack of activities that related to the tsunami issues, thus most of activity related to science with engineering design and less using STEM context. 29 elementary students followed the implementation of camp activity; the problem of this implementation was the less related solution design result that made by students; however, it took fair cost for the program conductor.

In 2014 camp activities, developing material or adopting a program for STEM took more than one month, it was conducted by faculty collogues, graduate students, and relevant community in accessible place. It produced problem based learning instruction that related to the theme of natural hazard disaster, where the activities were divided into four subthemes: tsunami, volcanoes, fire, and nuclear radiation, and using multiple intelligences (MI) approach. The problem occurred

in designing booth activity where the participant took less responsibility that impact on the longer time in achieving agreement and producing the materials. The implementation of STEM camp activity took two days in Yaizu that easy to be accessed by the participants. It resulted better STEM knowledge description and solution design in using STEM context than last year camp activities. However, both implementation gave more benefit to students and took much cost to the program conductor.

In Indonesia, developing materials or adopting a program for STEM was conducted more than one month during teacher training program. It was done by faculty collogues and teachers. The product of this implementation was the learning instruction that face difficulty in providing materials that coherent to standard and curriculum. Moreover, the implementation program was designed for more than one year that applied in the secondary level students that targeted to produce higher achievement in science.

c. Practice

In 2013 camp activity, adapting materials to unique took more than four months. It actively engaged faculty collogues and relevant community to produce simple materials that needed by students. However, it used less STEM context, and more cost to the program conductor

In 2014 camp activities, changing teaching strategies for STEM took more than four months. Graduate students and relevant community at university conducted it. The output of these activities was better teaching strategy reflected from better instruction in every booth and ‘ice breaking’ activities. It also took more than 4 months in adapting materials to unique needs of students because the lack participation of the participant, and unqualified communication among participant. Therefore it took more time in preparing the materials and resulted varied perception of using STEM contexts in each booth activity and solution design.

In Indonesia, the first implementation of STEM education was oriented at formal field, but then changed at informal field. The changing teaching strategy took more than one month; it involved colleagues, students, and parents. The informal implementation took more cost to the student, thus it produced simple materials in order to minimize the cost. It produced better implementation strategy in using STEM context than the previous one.

In conclusion, the challenges arose from the difficulty of finding the appropriate model of STEM integration in all activity and learning process. Thus, it needed the improvement of the knowledge and professionalism in STEM education field.

Based on the implementation result at informal learning, there are some element should be improved:

a) The coherency of booth activities and camp issues solution

b) Enhance attitude toward STEM fields and careers

c) Increase STEM knowledge and skills through students' autonomy

Furthermore, based on implementation result at formal learning, there are some element should be improved:

a) A coherent set of standard and curriculum

b) Teacher with high capacity to teach these disciplines

c) A supported system and assessment

d) Adequate instructional time

CHAPTER VI
SUMMARY AND CONCLUSIONS

INTRODUCTION

This study was triggered by the demands in 21st century that stimulated educational reform. In Japan, according to a survey commissioned by MEXT, on top of the maximally projected increase in researchers, an additional 0.16 million researchers and 1.09 million engineers will be required by 2030 in order to preserve an annual economic growth rate of 2 percent (MEXT 2006:91-104) and due to declining fertility rates and rapid aging of the population, they were still wondering whether or not these demand could be fulfilled in the future. On the other hand, Indonesia would need 113 million skilled workers in 2030, thus we need to improve quality and relevancy in education because it was critical to economic and social development (Ministry of Culture and Education, 2013). Therefore STEM education implementation assumed could help fulfill the demands of both countries. The implementation study is summarized in this chapter. It was divided into four sections: 1) summary of methodologies; 2) general analysis result; 3) limitation of the designs and results, and 4) further research consideration.

SUMMARY OF METHODOLOGY

The study has two main questions: 1) how was students' multiple intelligences profile in Indonesia differ to students' profile in Japan; and 2) How was STEM education implementation in Japan differs from Indonesia. The questions were specified as following:

Concerning to Multiple Intelligences (MI) study:

1. How undergraduate student's multiple intelligences profile in Indonesia was differs to student's profile in Japan?
2. How middle school student's multiple intelligences profile in Indonesia was differs to student's profile in Japan?
3. How differ was the student's multiple intelligences (MI) profile before and after learning process in one semester?

Concerning to STEM Camp 2013

4. How was student knowledge of tsunami changed before and after STEM camp?

5. How was student creativity changed in solving *tsunami* problem?
6. Were students shown MI characteristic based on their strength/dominant intelligences profile?
7. What were the challenges arose in this first implementation?

Concerning to STEM Camp 2014

8. How were students' knowledge of natural disaster and STEM before and after STEM camp differs?
9. Did students show MI characteristic coherent to their strength / dominate intelligences?
10. How were students' creativity skills profiles before and after STEM camp activities differ?
11. How was students' creativity skills changed in solving the problem?
12. How were students' response profiles to STEM education implementation?
13. What did the challenges arouse in this second implementation?

Concerning to STEM education implementation in Indonesia school

14. How was teacher perception changed of STEM integration based on KTSP and 2013 curriculum?
15. How was teachers' self-reflective changed on the implementation?
16. How does STEM education application in classroom?
17. How was students' response profile to the implementation?
18. How were students' creative thinking skills profiles in solving problem?
19. How was the implementation result differs without and with considering multiple intelligences?
20. What did the challenges arouse in this implementation?

In order to collect information as a respond to the above questions, the data were collected from undergraduate, middle school, and STEM camp participant student. The assessment instruments were used in collecting data includes:

1. Multiple Intelligences (MI) profile:

- Multiple Intelligences Survey (McKenzie, 1998)
- How Many Intelligences Are You Dominated (Laura Cadler, 2011)
- Multiple Intelligences Quiz (adapted from ITC Publication, 2008)
- MI Characteristics Observation Sheet

2. Students' Knowledge

- Mind Map Rubric Assessment
- Concept Map Rubric Assessment

3. Creativity
- Torrance Test of Creative Thinking
- Creativity Rubric of Tsunami
- Creativity Rubric of Natural Hazard Disaster

4. STEM Semantic Survey
5. STEM Implementation Questionnaire

GENERAL ANALYSIS RESULT

The analysis of STEM education implementation in Japan and Indonesia were divided into four main foci: multiple intelligences profile, impact of STEM education implementation to students' knowledge, students' creativity in STEM education implementation activity, respond toward implementation, and multiple intelligences approach in the implementation. Based on the research questions, the general analyses of the implementation result are:

1. Multiple intelligence (MI) profile:

- There was significant different of multiple intelligences profile between Japanese and Indonesian undergraduate science students. Japanese and Indonesian students have some differences in estimating their intelligences. They differ in less developed intelligences, and similar in logical mathematical intelligences area. It was the most difference significant among students of each major, even though compare to Indonesian, Japanese students have lower score.
- There were significant differences of multiple intelligences profile between Japanese and Indonesian middle school students. In general, Japanese students estimate their logical mathematical, existential, social interpersonal and intrapersonal intelligences lower than Indonesia significantly.
- There were significant differences of multiple intelligences (MI) profile in one semester. The result showed students estimated their logical mathematical higher in one semester. It was higher than three other intelligences (EI, NI, and SI) and lower than VL and MR. It was supported by statistical test that showed t-observed values in all areas of intelligence were exceeding the t critical value.

2. Impacts of STEM education implementation to students' knowledge

- In STEM camp 2013, almost all group showed that there was increase of students' knowledge before and after camp activity, except the C group students.

- In STEM camp 2014, there was an increase of STEM knowledge understanding before and after camp activity. Furthermore, it was founded that students' learning experiences in booth activities influenced their STEM knowledge understanding in creating solution ideas for the disaster. It gave clear evidence that the booth activities as one of camp activity gave great impacts to their STEM knowledge understanding.

- In Indonesia, there was no significant difference between learning process that integrated STEM and the learning process without integrated it. But, generally the average score of total examination and students' scores at STEM integration related item were different in the both classes. It showed that students who used STEM integration achieved higher average score than students who did not use it.

3. Students' creativity skills in STEM education implementation activities

- In 2013 camp activities, there were no significant differences of creativity skills between groups of dominated intelligences. However, all group showed increases in creativity skills average scores before and after camp activities. Moreover, some of students' ideas came from booth activities ideas. In general, the D group students who were dominated in naturalist intelligence got the highest number of related words.

- In 2014 camp activities, there were significant differences of creativity skills profiles before and after STEM activity in the level of confidence 95% at alpha 0.05, where the Wilcoxon observed value (W_{ov}= 60) did not exceed the Wilcoxon critical value (W_{cv}= 77). Furthermore, from the solution designs, the C group students who were dominated in logical mathematical, achieved highest score of creativity skill.

- In Indonesia, most of students' solution designs were related to alarm sensor, they design the flood detector to prevent the flood disaster. The students were

fluency and flexible in solving the flood problem. It showed from average score that higher than other categories. However, the originality of the solving problem was lower than other category because most students had common ideas.

4. Response toward STEM education implementation

- In 2014 camp activities, the students' perspectives of STEM content was different significantly before and after camp, but there was no different significantly for STEM interest and agreement before and after camp. In general, students were most interested in science than other disciplines, chosen most career in science, and agreed that having a careers in science, would be challenging.
- In Indonesia, there were significant differences of teacher perception toward science, engineering, mathematics, STEM career, and STEM integration. In general, most of teachers put positive agreements toward STEM education implementation (100%). They perceived that STEM education implementation was applicable (56,3% agree, 37.25% strongly agree), easy to do because they agreed the STEM integration was not hard to do (81.3%), and they suggested the continuous training in STEM education (56.25% strongly agree, 43.75% agree).
- In Indonesia, elementary students put interests to join the lesson, 75% students moved actively, engaged the lessons and did the activities, but 75% of them said that they didn't much understand the lessons. On the other hand, almost all secondary students were enjoying the lessons, they said they were happy to join the lessons, 90% students were moving actively in lessons, engaged and did activities that teacher asked to do, and 80% student understood of motion, distance and displacement, but they confused of linear motion concept because some of their data did not show its characteristic.

5. Multiple intelligences approach in the STEM education implementation

- In 2013 camp activities, most of groups showed their MI characteristics consistency to MI self-estimate profile. The A group students showed the

highest consistencies ($r_A = 0.708$) than other groups. On the other hand, the other R-value of B, C, D, and E group students showed lower consistencies ($r_B = 0.457$, $r_C = 0.405$, $r_D = 0.476$, and $r_E = 0.4$).

- In 2014 camp activities, most of students showed consistencies of their MI self-estimate profiles and its characteristics. The A and D group had 'high' positive correlation ($r_A = 0.823$, $r_D = 0.885$), while the B group had 'middle' positive correlation ($r_B = 0.682$), and the C group have 'low' positive correlation ($r_C = 0.221$). However, there was not significant difference in students' multiple intelligences self-estimate before and after camp activity.
- In Indonesia, there was no significant difference between learning processes that integrated STEM using MI approach and the learning processes without integrated it. But, generally the average score of total STEM integration with (5.69) and without MI (5.467) approach related item were different in the both classes. It showed that students who have MI approach achieved higher average score than students who have not used it. On the other hand, the impacts of learning process in the class that using MI approach, showed significant difference of multiple intelligence profile in one semester.

LIMITATION OF STUDIES AND RESULTS

The limitation of study and results were derived from challenges analyses of STEM education implementation in Japan and Indonesia.

The limitations are:

1. the difficulty finding the appropriate model of STEM integration on every activity and learning processes. It was emphasized more on difficulty of implementing of technology (T) and engineering (E) into specified theme. It arrived from the lack of STEM area recourses and professionals.
2. the coherency of standards and school curriculum that could support STEM education implementation. It takes many risks to students and teachers in the formal implementation so that it needed new policy of school curriculum without neglected the national science standard and competence.
3. the limited number of sample. These studies were the first STEM education implementation in both countries, thus they were conducted using small scope of sample.

4. Concerning to the instrument to analyze intelligences diversities among participants. Some of instruments were not valid and reliable in collecting students' intelligence diversity.

FURTHER RESEARCH CONSIDERATION

Based on the limitations of these studies and results, there are several considerations for further research:

1. The STEM area resources and professionals should be improved through a periodic professional development of STEM education, and the collaboration among STEM area professionals should be involved in order to enrich the resources and to equate the perception.
2. At the formal setting education, agreement with schools sample to applied STEM education based curriculum should be achieved in order to improve STEM education implementation. At the informal setting education, standard competences that refer to the program goals should be created in order to improve STEM education implementation impact.
3. We should actively engage the faculty collogues, relevant community and other assets to increase number of participant into the STEM education implementation program in order to improve the analysis and spread out the implication of STEM education.
4. We should use the instrument that could measure valid and reliable students' multiple intelligences diversity by creating more chosen statement of specific characteristics that could be well estimated by students.

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APPENDIX A

1.1 TIMSS Result 2007

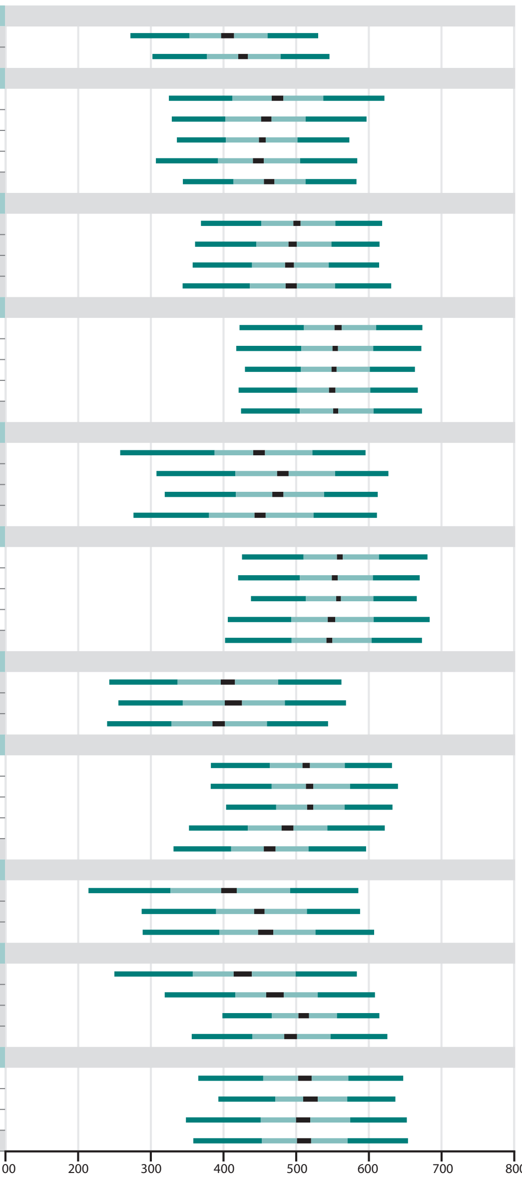
Exhibit 1.6: Trends in Science Achievement (Continued)

TIMSS 2011 Science 8th Grade

Instructions: Read across the row to determine if the performance in the row year is significantly higher (▲) or significantly lower (▼) than the performance in the column year.

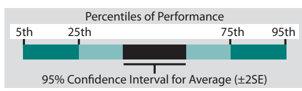
Country		Average Scale Score	Differences Between Years 2007	2003	1999	1995
Indonesia						
	2011	406 (4.5)	−21 ▼			
1	2007	427 (3.4)				
Iran, Islamic Rep. of						
	2011	474 (4.0)	15 ▲	21 ▲	26 ▲	12 ▲
	2007	459 (3.6)		6	11 ▲	−4
2	2003	453 (2.3)			5	−9 ▼
	1999	448 (3.8)				−15 ▼
	1995	463 (3.6)				
Italy						
	2011	501 (2.5)	6	10 ▲	8	
	2007	495 (2.8)		4	2	
	2003	491 (3.1)			−2	
2	1999	493 (3.9)				
Japan						
	2011	558 (2.4)	4	6	8 ▲	3
	2007	554 (1.9)		2	4	−1
	2003	552 (1.7)			3	−2
	1999	550 (2.2)				−5
	1995	554 (1.8)				
Jordan						
	2011	449 (4.0)	−33 ▼	−26 ▼	−1	
	2007	482 (4.0)		7	31 ▲	
	2003	475 (3.8)			25 ▲	
	1999	450 (3.8)				
Korea, Rep. of						
	2011	560 (2.0)	7 ▲	2	12 ▲	14 ▲
	2007	553 (2.0)		−5 ▼	4	7 ▲
⧓	2003	558 (1.6)			10 ▲	13 ▲
	1999	549 (2.6)				3
	1995	546 (2.0)				
Lebanon						
	2011	406 (4.9)	−8	13		
	2007	414 (5.9)		20 ▲		
	2003	393 (4.3)				
Lithuania						
1	2011	514 (2.6)	−5	−6	26 ▲	50 ▲
1	2007	519 (2.5)		−1	30 ▲	55 ▲
1	2003	519 (2.1)			31 ▲	56 ▲
1 ⧓	1999	488 (4.1)				25 ▲
1 2	1995	464 (4.0)				
Macedonia, Rep. of						
	2011	407 (5.4)		−42 ▼	−51 ▼	
3	2003	449 (3.6)			−9	
	1999	458 (5.2)				
Malaysia						
	2011	426 (6.3)	−44 ▼	−84 ▼	−66 ▼	
	2007	471 (6.0)		−40 ▼	−22 ▼	
	2003	510 (3.7)			18 ▲	
	1999	492 (4.4)				
New Zealand						
	2011	512 (4.6)		−8	2	1
	2003	520 (5.0)			10	9
	1999	510 (4.9)				−1
	1995	511 (4.9)				

Science Achievement Distribution



▲ More recent year significantly higher

▼ More recent year significantly lower



SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

1.2. PISA Result 2012

Snapshot of performance in mathematics, reading and science

Countries/economies with a mean performance/share of top performers above the OECD average
Countries/economies with a share of low achievers below the OECD average

Countries/economies with a mean performance/share of low achievers/share of top performers not statistically significantly different from the OECD average

Countries/economies with a mean performance/share of top performers below the OECD average
Countries/economies with a share of low achievers above the OECD average

	Mathematics				Reading		Science	
	Mean score in PISA 2012	Share of low achievers in mathematics (Below Level 2)	Share of top performers in mathematics (Level 5 or 6)	Annualised change in score points	Mean score in PISA 2012	Annualised change in score points	Mean score in PISA 2012	Annualised change in score points
OECD average	494	23.0	12.6	**-0.3**	496	**0.3**	501	**0.5**
Shanghai-China	613	3.8	55.4	**4.2**	570	**4.6**	580	1.8
Singapore	573	8.3	40.0	**3.8**	542	**5.4**	551	**3.3**
Hong Kong-China	561	8.5	33.7	**1.3**	545	**2.3**	555	**2.1**
Chinese Taipei	560	12.8	37.2	1.7	523	**4.5**	523	-1.5
Korea	554	9.1	30.9	1.1	536	**0.9**	538	**2.6**
Macao-China	538	10.8	24.3	**1.0**	509	**0.8**	521	**1.6**
Japan	536	11.1	23.7	0.4	538	**1.5**	547	**2.6**
Liechtenstein	535	14.1	24.8	0.3	516	**1.3**	525	0.4
Switzerland	531	12.4	21.4	0.6	509	**1.0**	515	0.6
Netherlands	523	14.8	19.3	**-1.6**	511	-0.1	522	-0.5
Estonia	521	10.5	14.6	0.9	516	**2.4**	541	1.5
Finland	519	12.3	15.3	**-2.8**	524	**-1.7**	545	**-3.0**
Canada	518	13.8	16.4	**-1.4**	523	**-0.9**	525	**-1.5**
Poland	518	14.4	16.7	**2.6**	518	**2.8**	526	**4.6**
Belgium	515	19.0	19.5	**-1.6**	509	0.1	505	-0.9
Germany	514	17.7	17.5	**1.4**	508	**1.8**	524	1.4
Viet Nam	511	14.2	13.3	m	508	m	528	m
Austria	506	18.7	14.3	0.0	490	-0.2	506	-0.8
Australia	504	19.7	14.8	**-2.2**	512	**-1.4**	521	-0.9
Ireland	501	16.9	10.7	-0.6	523	**-0.9**	522	**2.3**
Slovenia	501	20.1	13.7	-0.6	481	**-2.2**	514	-0.8
Denmark	500	16.8	10.0	**-1.8**	496	0.1	498	0.4
New Zealand	500	22.6	15.0	**-2.5**	512	**-1.1**	516	**-2.5**
Czech Republic	499	21.0	12.9	**-2.5**	493	-0.5	508	-1.0
France	495	22.4	12.9	**-1.5**	505	0.0	499	0.6
United Kingdom	494	21.8	11.8	-0.3	499	0.7	514	-0.1
Iceland	493	21.5	11.2	**-2.2**	483	**-1.3**	478	**-2.0**
Latvia	491	19.9	8.0	0.5	489	**1.9**	502	**2.0**
Luxembourg	490	24.3	11.2	-0.3	488	**0.7**	491	0.9
Norway	489	22.3	9.4	-0.3	504	0.1	495	1.3
Portugal	487	24.9	10.6	**2.8**	488	**1.6**	489	**2.5**
Italy	485	24.7	9.9	**2.7**	490	0.5	494	**3.0**
Spain	484	23.6	8.0	0.1	488	-0.3	496	1.3
Russian Federation	482	24.0	7.8	1.1	475	**1.1**	486	1.0
Slovak Republic	482	27.5	11.0	**-1.4**	463	-0.1	471	**-2.7**
United States	481	25.8	8.8	0.3	498	-0.3	497	1.4
Lithuania	479	26.0	8.1	-1.4	477	1.1	496	1.3
Sweden	478	27.1	8.0	**-3.3**	483	**-2.8**	485	**-3.1**
Hungary	477	28.1	9.3	**-1.3**	488	**1.0**	494	-1.6
Croatia	471	29.9	7.0	0.6	485	1.2	491	-0.3
Israel	466	33.5	9.4	**4.2**	486	**3.7**	470	**2.8**
Greece	453	35.7	3.9	**1.1**	477	0.5	467	-1.1
Serbia	449	38.9	4.6	**2.2**	446	**7.6**	445	1.5
Turkey	448	42.0	5.9	**3.2**	475	**4.1**	463	**6.4**
Romania	445	40.8	3.2	**4.9**	438	1.1	439	**3.4**
Cyprus[1, 2]	440	42.0	3.7	m	449	m	438	m
Bulgaria	439	43.8	4.1	**4.2**	436	0.4	446	2.0
United Arab Emirates	434	46.3	3.5	m	442	m	448	m
Kazakhstan	432	45.2	0.9	**9.0**	393	0.8	425	**8.1**
Thailand	427	49.7	2.6	1.0	441	**1.1**	444	**3.9**
Chile	423	51.5	1.6	**1.9**	441	**3.1**	445	1.1
Malaysia	421	51.8	1.3	**8.1**	398	**-7.8**	420	-1.4
Mexico	413	54.7	0.6	**3.1**	424	**1.1**	415	0.9
Montenegro	410	56.6	1.0	**1.7**	422	**5.0**	410	-0.3
Uruguay	409	55.8	1.4	**-1.4**	411	**-1.8**	416	**-2.1**
Costa Rica	407	59.9	0.6	-1.2	441	-1.0	429	-0.6
Albania	394	60.7	0.8	**5.6**	394	**4.1**	397	2.2
Brazil	391	67.1	0.8	**4.1**	410	**1.2**	405	**2.3**
Argentina	388	66.5	0.3	1.2	396	-1.6	406	2.4
Tunisia	388	67.7	0.8	**3.1**	404	**3.8**	398	**2.2**
Jordan	386	68.6	0.6	0.2	399	-0.3	409	**-2.1**
Colombia	376	73.8	0.3	1.1	403	**3.0**	399	1.8
Qatar	376	69.6	2.0	**9.2**	388	**12.0**	384	**5.4**
Indonesia	375	75.7	0.3	0.7	396	**2.3**	382	-1.9
Peru	368	74.6	0.6	1.0	384	**5.2**	373	1.3

1. Footnote by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".
2. Footnote by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

The annualised change is the average annual change in PISA score points from a country's/economy's earliest participation in PISA to PISA 2012. It is calculated taking into account all of a country's/economy's participation in PISA.

Note: Countries/economies in which the annualised change in performance is statistically significant are marked in bold.
Countries and economies are ranked in descending order of the mean mathematics score in PISA 2012.

Source: OECD, PISA 2012 Database; Tables I.2.1a, I.2.1b, I.2.3a, I.2.3b, I.4.3a, I.4.3b, I.5.3a and I.5.3b.

APENDIX A. 1.2

LIST OF SCIENCE AND MATH CONTENT MATTERIALS IN 2013 & KTSP CURICULUM

KTSP				2013			
Grade	**Theme**	**Science**	**Math**	**Grade**	**Theme**	**Science**	**Math**
		Materials scope: - Living things and process of life: - Objects / materials, properties and usefulness. - Energy and changes - Earth and Universe	Materials scope: - Numbers - Geometry and measurement - Data processing	1st	- M Self - My interest - My Activity - My Experience - The Environment - Objects, Plants, Animals in surrounding - Natural events	Competence Level :I Material Scope: - The body and the senses - Plant and animals - Properties and form of objects around student - Universe and their appearance	Competence Level 1 Materials scope: - Real numbers and simple fractions - Geometry and simple measurement - Simple statistic MATERIALS - Addition and subtraction of real number - Classify object based on the shape - Effect of addition and subtraction from a group of object - Identify whole and part of everyday life - Use picture or photo to state information and answer question - Using concrete models in problem solving
1st	- Daily activities - Animals and plants - Character - Health and hygiene - My Interest - The environment - Family - My Self - Transportation.	MATERIALS - Part of body - Keep a healthy environment - Identify object/ materials and its changes - Form of energy and its use Celestial objects and natural events (weather and season) and its influence on human activity.	MATERIALS - Addition and subtraction until 20 - Measure time and length - Addition and subtraction of two numbers Measure mass				

2nd	- Events - Health - My Self - Entertainment - Environment - Public places - Animal and Plant - Character - My Interest - Daily activity	- The main body of animals and plants, its growth as well as a variety of living things - Various shapes of objects and their use and change of state that can be experienced - Energy sources that often encountered in everyday life and usefulness - The influence of the sun in everyday life	- Addition and subtraction until 500 - Measure time, length and mass in a problem - Multiplication and division until two numbers - Simple geometry (flat figures)	2nd	- Live in harmony - Play in my neighbor - My daily task - Me and My School - Healthy and Clean Life - Water, Earth, and Sun - Taking care of animals and plants - Safety in home and on the go		
3rd	- Experience - Environment - Activities - Public Places - Entertainment - Health - Agriculture - Daily Needs - Hand Craft - The interest - Education - Games	- Characteristics and needs of living things and the its changing affect in living things - Environmental conditions' effect on health, and efforts to maintain a healthy environment - Properties, its changing and usefulness in everyday life - Motion of objects, its relation to energy and energy sources - Apply motion energy concept - Earth surface, cloud and weather	- Counting operation of three numbers - Measure time, length and mass in a problem - Simple fraction and its uses in problem - Count circumference & extensive of square and rectangular	3rd	- Environment - Health - Events - Culture	Competence level: II Material Scope: - Outside the body shapes of animals and plants - Life cycle of living things - Plant growth - State of object - Force and motion - Forms and sources of energy and alternative energy - Earth surface and its changes	Competence Level : II Material Scope: - Integers and fractions - Geometry (properties and elements) and measurement (standard units) - Statistic (Simple data collection and presentation) MATERIALS: - Addition and subtraction of whole numbers and fractions - Classify objects according to the shape and its justification - Daily arithmetic problems as the application of an
4th		- Relationship between the structure of human body	- Properties of counting operation in math	4th	- The beauty of togetherness		

		organ, function, and maintenance - The relationship between the structure of the plant with its function - Classify animals, by food type - Life cycle of various living things' types - Relationships among and between living things with their environment - Object properties, its change of state, and usefulness based on the properties. - Force change the motion - Form of energy - Change of earth surface and celestial bodies - Relationship between natural resources with the environment, technology, and society	problem - Factors and multiples in problem solving - Measure angel, mass, and length in math problem - Use concept of circumference and extensive in math problem - Addition and subtraction of integer - Fraction, and Roman symbols - Simple geometry and its relation to flat		- Always save energy - Share the work - Hero - Beauty of My Country - My dream/ goal - Where I live - Healthy and nutritious food	- Environment, universe and natural resources - Climate and weather	understanding of the effect of the addition and subtraction - Object that viewed as the union of its parts - Provide Interpretation of a presentation of information / data - Using Symbolic or concrete models and other strategies in problem solving day-to-day
5th		- Function of human and animal organs - Photosynthesis - Animal and plant adaptation to environment - Relationship between the properties of the constituent materials and natural changes of things as a result of a process - Relationship force, motion energy and its function	- Counting operation of integer in problem - Measure time, angel, distance, and velocity in problem - Measure area of flat figures - Measure volume of cube and beam - Use fraction in problem - Properties and relation of geometries	5th	- Objects in the surrounding - Events and Live - Harmony in society - Health is important - Proud as Indonesian - Plants and Animal Organ - Indonesia	Competence Level: III Material Scope: - Human and animal skeleton organs - Food, food chain, and the balance of the ecosystem - Living things breeding	Competence Level: III Material Scope: - Numbers (including rank and simple roots) - Geometry and Measurement (including derivative units) - Statistic and probability MATERIALS: - Flat figures pattern to draw conclusions or

		- Applying the properties of light through making a work / model - Changes that occur in nature and its conjunction with the use of natural resources			History - Ecosystem - Environment is our friend	- Adaptation of living beings on the environment - Health and human respiratory system - Objects' properties, heat transfer, electricity, and magnets - Solar system - Composite and solutions	formulate evidence / justification simple - Addition, subtraction, multiplication and division of whole numbers and fractions - Space objects classification by their properties - Provide estimates of problem solving and compare it with the calculated - Provide visualization and description and use proportions and problem solving - Collect relevant data and presenting it in the form of tables, images, lists - Using Symbol in modeling, identifying information, use other strategies if not successful
6th		- Relationship between the characteristics of living things to the environment - Living things reproduction - Human activity and the influence to ecosystem - Living thing conservation - Relationship between temperature, heat transfer and usefulness of object - Weathering, corrosion, and decay - Practice and use of energy transfer - The importance of energy savings - Sun as a center of solar system, and earth interaction in solar system	- Calculate integer fraction by factors and multiples in problem - Measure volume per time in problems - Calculate the area of polygons, circle, and volume of triangle prism. - Data collection and processing - Calculate counting operation in fraction - Using coordinate system in problem solving - Solving problem that related to data	6th	- Save Living Things - *Bhineka Tunggal Ika* (Unity of Indonesia) - Leaders and Inventors - Globalization - Entrepreneurship - Society Healthy		

APENDIX B

THE RESEARCH INSTRUMENTS

1. Multiple Intelligences Survey for undergraduate level

1.a. Bahasa Indonesia Version

<u>Multiple Intelligences Survey</u>

The One and Only Surfaquarium

http://surfaquarium.com/MI/inventory.htm

<u>Part I</u>

Lengkapi setiap sesi dengan menuliskan "1" di samping pernyataan yang menurut anda mengambarkan diri anda, jika pernyataan tersebut tidak sesuai dengan diri anda, maka biarkan bagian isian tersebut kosong. Kemunian jumlahkan angka tersebut pada setiap sesi.

Sesi 1

_____ Saya senang mengkategorikan sesuatu dengan ciri-ciri yang umum
_____ Isu-isu ekologi penting untuk saya
_____ Klasifikasi membantu saya dalam merasakan makna dari data baru
_____ Saya senang bekerja di taman
_____ Saya yakin Taman Nasional penting dilestarikan.
_____ Menempatkan seuatu secara hirarki merupakan hal yang masuk akal untuk saya.
_____ Binatang sangat penting dalam hidup saya
_____ Rumah saya mempunyai sistem daur ulang (*recycling)*
_____ Saya senang mempelajari biologi, botani dan atau zoologi
_____ Saya menangkap perbedaan yang tipis dalam sebuah makna
_____ JUMLAH untuk Sesi 1

Sesi 2

_____ Saya mudah memilih pola
_____ Saya dapat fokus dalam kebisingan dan suara
_____ Menari berdasarkan irama musik mudah bagi saya
_____ Saya senang membuat musik
_____ Saya tertarik dengan irama puisi
_____ Saya mudah mengingat seuatu jika dibuat menjadi sebuah sajak
_____ Saya sulit berkonsentrasi jika keadaan disekeliling saya rebut.
_____ Mendengarkan suara-suara dari alam dapat membuat saya rileks.
_____ Saya lebih menyukai music daripada drama teater
_____ Saya mudah mengingat syair lagu
_____ JUMLAH untuk sesi 2

Sesi 3

_____ Saya adalah orang yang rapih dan teratur
_____ Arahan tahap demi tahap sangat membantu saya
_____ Saya mudah memecahkan masalah
_____ Saya mudah jadi fustasi jika berhadapan dengan orang yang tidak teratur/rapih
_____ Saya dapat menyelesaikan hitungan matematika dengan cepat di luar kepala
_____ Teka-teki logika sangat menyenangkan
_____ Saya tidak dapat mulai mengerjakan tugas, jika semuanya belum teratur
_____ Sesuatu yang terstruktur merupakan hal yang baik.
_____ Saya senang memecahkan masalah dari sesuatu yang tidak bekerja dengan baik
_____ Sesuatu hal harus masuk akal untuk saya, jika tidak maka saya akan kecewa
_____ JUMLAH untuk Sesi 3

Sesi 4

______ Sangat penting bagi saya untuk melihat peran saya dalam sebuah "poster besar"
______ Saya senang berdiskusi tentang kehidupan
______ Agama merupakan hal yang penting bagi saya
______ Saya senamg menikmati karya seni
______ Latihan relasasi dan meditasi sangat berharga bagi saya
______ Saya senang traveling mengunjungi tempat tempat yang inspiratif
______ Saya senang membaca filosofi
______ Mempelajari sesuatu hal baru akan lebih mudah jika saya melihat aplikasinya secara nyata
______ Saya I wonder if there are other forms of intelligent life in the universe
______ Penting bagi saya untuk mengetahui dan mengenal orang, ide dan keyakinan
______ JUMLAH untuk sesi 4

Sesi 5
______ Saya dapat belajar banyak ketika berinteraksi dengan orang lain.
______ Saya menyukai obrolan santai dan diskusi yang serius
______ Makin banyak orang makin meriah
______ Saya sering dijadikan pemimpin diantara teman sebaya dan kolega
______ Saya menghargai suatu hubungan lebih dari sebuah ide atau prestasi
______ Belajar secara berkelompok merupakan hal yang produktif bagi saya
______ Saya seorang "team player"
______ Perteman sangat merupakan hal penting bagi saya
______ Saya terlibat lebih dari tiga klub dan organisasiI
______ Saya tidak suka bekerja sendiri
______ JUMLAH for Sesi 5

Sesi 6
______ Saya belajar dengan melakukan sesuatu (learn by doing)
______ saya senang membuat sesuatu dengan tangan saya
______ Olahraga merupakan bagian hidup saya
______ Saya menggunakan isyarat sikap dan isyarat non-verbal lainnya ketika berkomunikasi
______ Demonstrasi (peragaan) lebih baik daripada ceramah (penjelasan)
______ Saya senang menari
______ Saya senang bekerja dengan alat-alat
______ Tidak ada aktivitas membuat saya lebih cepat lelah dibandingkan ketika saya sibuk
______ Kegiatan praktikum sangat menyenangkan
______ Saya hidup dalam gaya hidup yang aktif
______ JUMLAH for Section 6

Sesi 7
______ Saya menyukai bahasa asing
______ Saya senang membaca buku, majalah dan web site
______ Saya senang mengumpulkan jurnal
______ Teka-teki silang sangat menyenangkan
______ mencatat sesuatu sangat membantu saya dalam mengingat dan memahami
______ Saya menghunungi teman saya melalui surat dan atau e-mail
______ Saya dapat menjelaskan ide-ide saya kepada orang lain dengan mudah
______ Saya senang menulis di waktu luang saya
______ Permainan kata-kata, huruf dan *spoonerisme (merubah susunan inisial)* sangat menyenangkan

_____ Saya menyenangi *public speaking* dan berpartisipasi dalam debat
_____ JUMLAH for Section 7

Sesi 8
_____ Sikap saya mempengaruhi cara saya belajar
_____ Saya merasa senang jika dilibatkan dalam hal/kegiatan yang dapat membantu orang lain
_____ Saya sangat sadar terhadap keyakinan saya
_____ Saya belajar dengan baik ketika saya mempunyai perasaan emosional terhadap subjek materi tersebut.
_____ Keadilan sangat penting bagi saya
_____ Saya tertarik terhadap masalah hukum
_____ Bekerja sendiri sama produktifnya dengan bekerja dalam kelompok
_____ Saya perlu mengetahui alas an mengapa saya mengerjakan sesuatu sebelum saya menyetujui untuk mengerjakannya
_____ Ketika saya percaya akan sesuatu hal, maka saya akan memberikan usaha yang lebih terhadap hal tersebut.
_____ Saya berani mengajukan protes atau petisi untuk memperbaiki sesuatu hal yang salah
_____ Jumlah untuk sesi 8

Sesi 9.
_____ Saya dapat memvisualisasikan ide-ide dalam benak saya
_____ Mengatur dan mendekorasi kembali sebuah ruangan sangat menyenangkan untuk saya
_____ Saya senang menciptakan karya seni saya sendiri
_____ Saya akan mengingat dengan lebih baik dengan menggunakan pengaturan grafik
_____ Saya menikmati semua jenis media entertainment
_____ Diagram, grafik dan tabel dapat membantu saya dalam mengintrepretasikan data
_____ Video music dapat membuat saya lebih tertarik terhadap musik.
_____ Saya dapat mengingat sesuatu hal sebagai *mental picture*
_____ Saya ahli dalam membaca meta dan *blueprints*
_____ Puzzle 3 dimensi sangat menyenangkan
_____ Jumlah untuk 9

Part II . Simpanlah nilai jumlah untuk setiap sesi dalam kolom di bawah ini kemudian dikali 10:

Sesi	Jumlah	Dikali	Skor
1		X10	
2		X10	
3		X10	
4		X10	
5		X10	
6		X10	
7		X10	
8		X10	
9		X10	

Part III. Plot *score* anda dalam bentuk diagram batang pada kolom di bawah ini

100									
90									
80									
70									
60									
50									
40									
30									
20									
10									
0	Sesi 1	Sesi 2	Sesi 3	Sesi 4	Sesi 5	Sesi 6	Sesi 7	Sesi 8	Sesi 9

1.b. Japanese and English version

Multiple Intelligences Survey

© 1999 Walter McKenzie, The One and Only Surfaquarium

http://surfaquarium.com/MI/inventory.htm

Part I

Complete each section by placing a “1” next to each statement you feel accurately describes you. If you do not identify with a statement, leave the space provided blank. Then total the column in each section.

的確に自分を説明していると感じる文章には「１」を書き込み、そうでなければ空欄のままにしておいてください。終わったら最後の行のTOTAL lに「１」の合計を書いてください。

Section 1

_____ I enjoy categorizing things by common traits
私は共通な特徴によってカテゴリー分けすることを楽しいと感じる。

_____ Ecological issues are important to me
生態学的問題は私にとって大切である。

_____ Classification helps me make sense of new data
分類分けは自分にとって新しいデータの意味を理解する助けとなる。

_____ I enjoy working in a garden
私は庭で活動 (作業) することを楽しいと感じる。

_____ I believe preserving our National Parks is important
私は国立公園の保護は大切であると思う。

_____ Putting things in hierarchies makes sense to me
物事を階層化することは自分にとって理解しやすくなる方法だ。

_____ Animals are important in my life

私の生活のなかで、動物は大切である。
_____ My home has a recycling system in place
私の家はリサイクルシステムが整っている。
_____ I enjoy studying biology, botany and/or zoology
私は生物学、植物学や動物学を勉強することが楽しい。
_____ I pick up on subtle differences in meaning
私は微妙な意味の違いに気づくことができる。
_____ TOTAL for Section 1

Section 2
_____ I easily pick up on patterns
私は簡単にパターン(規則性)に気づくことができる。
_____ I focus in on noise and sounds
私は雑音や音に集中してしまう(きになってしまう)。
_____ Moving to a beat is easy for me
音にあわせて体を動かすことは簡単だ。
_____ I enjoy making music
私は音楽をつくることが楽しい。
_____ I respond to the cadence of poetry
私は詩のリズムに反応する。
_____ I remember things by putting them in a rhyme
私はリズムに乗せることで物事を覚える。
_____ Concentration is difficult for me if there is background noise
背景に雑音があると、集中することが難しい。
_____ Listening to sounds in nature can be very relaxing
自然の中で音を聞くことでとてもリラックスできる。
_____ Musicals are more engaging to me than dramatic plays
ミュージカルはお芝居よりも没頭することができる。
_____ Remembering song lyrics is easy for me
歌詞を覚えることは簡単である。
_____ TOTAL for Section 2
Section 3
_____ I am known for being neat and orderly
私はきちんとしていて、整頓家であることで知られている。
_____ Step-by-step directions are a big help
段階を追った指示は大きな助けとなる。
_____ Problem solving comes easily to me
問題解決は私にとって簡単なことだ。
_____ I get easily frustrated with disorganized people
私はすぐ、まとまりのない(でらための)人たちに腹が立つ。
_____ I can complete calculations quickly in my head
私は計算をすばやく暗算でできる。
_____ Logic puzzles are fun
ロジックパズル (論理パズル) は楽しい。
_____ I can't begin an assignment until I have all my "ducks in a row"
私は全ての必要な準備を整えるまでは、課題を始めることができない。
_____ Structure is a good thing
思考の構造化はよいものだ。
_____ I enjoy troubleshooting something that isn't working properly
私は正しく動かないものを修理することを楽しいと感じる。
_____ Things have to make sense to me or I am dissatisfied
意味がないと(論理的でないと)、私は満足できない。
_____ TOTAL for Section 3

Section 4
_____ It is important to see my role in the “big picture” of things
物事の全体像の中で、自分の役割をみることが大切である。
_____ I enjoy discussing questions about life
私は人生についての問題を議論することが楽しいと感じる。
_____ Religion is important to me
宗教は私にとって大切である。
_____ I enjoy viewing art work
私は芸術作品を鑑賞することが楽しい。
_____ Relaxation and meditation exercises are rewarding to me
リラクゼーションや瞑想は私にとって有益なものである。
_____ I like traveling to visit inspiring places
私は人を奮い立たせる場所を訪れることが好きだ。
_____ I enjoy reading philosophers
私は哲学書を読むことが楽しい。
_____ Learning new things is easier when I see their real world application
新しい物事を学ぶには現実世界への応用・活用をみた時の方が簡単だ。
_____ I wonder if there are other forms of intelligent life in the universe
宇宙には知的生命体の他の形があるのかどうか不思議に思う。
_____ It is important for me to feel connected to people, ideas and beliefs
私にとって人々や、考え、信念に繋がっていると感じることは大切である。
ると感じることは大切である。
_____ TOTAL for Section 4

Section 5
_____ I learn best interacting with others
私は他の人と相互に関わることでもっと学習できる。
_____ I enjoy informal chat and serious discussion
私は普段の会話と真面目な議論を楽しんでいる。
_____ The more the merrier
人は多い方が楽しい。
_____ I often serve as a leader among peers and colleagues
私はよく同僚の間でリーダーとして役目を果たす。
_____ I value relationships more than ideas or accomplishments
私は考えや成果よりも関係性を評価する。
_____ Study groups are very productive for me
グループ学習は私にとってとても生産性を高める。
_____ I am a “team player”
私は一人のチームプレーヤーである。
_____ Friends are important to me
友達は私にとって大切である。
_____ I belong to more than three clubs or organizations
私は3つ以上のクラブまたは団体に属している。
_____ I dislike working alone
私は一人で活動することが嫌いだ。
_____ TOTAL for Section 5

Section 6
_____ I learn by doing
私は成すことによって学ぶ（行動しながら学んでいる）。
_____ I enjoy making things with my hands
私は自分の手で何かを作ることが楽しい。
_____ Sports are a part of my life

スポーツは私の生活の一部だ。
_____ I use gestures and non-verbal cues when I communicate
私はコミュニケーションをするとき、ジェスチャーや非言語的合図を使う。
_____ Demonstrating is better than explaining
説明するよりも実際に見せた方がよい。
_____ I love to dance
ダンスをすることが大好きだ。
_____ I like working with tools
私は道具を使って作業をすることが好きだ。
_____ Inactivity can make me more tired than being very busy
活動しないことは、とても忙しくしているよりも疲れる。
_____ Hands-on activities are fun
体を動かす活動は楽しい。
_____ I live an active lifestyle
私は活動的な生活をしている。
_____ TOTAL for Section 6

Section 7
_____ foreign languages interest me
外国語は楽しい。
_____ I enjoy reading books, magazines and web sites
私は本、雑誌、ウェブサイトを読むことが楽しい。
_____ I keep a journal
日記を続けている。
_____ Word puzzles like crosswords or jumbles are enjoyable
クロスワードや ジャンブルのような言葉のパズルは楽しい。
_____ Taking notes helps me remember and understand
ノートをとることは、記憶することと理解の助けになる。
_____ I faithfully contact friends through letters and/or e-mail
私は友達と誠意をもって、手紙や/またはe-mail で連絡をする。
_____ It is easy for me to explain my ideas to others
私にとって相手に自分の考えを説明することは簡単である。
_____ I write for pleasure
私は楽しんで書いている。
_____ Puns, anagrams and spoonerisms are fun
ダジャレ、つづり換え、頭音転換は楽しい。
_____ I enjoy public speaking and participating in debates
私は演説をしたりディベートに参加することを楽しいと感じる。
_____ TOTAL for Section 7

Section 8
_____ My attitude effects how I learn
私の態度は何を学んでいるかに影響している。
_____ I like to be involved in causes that help others
私は人を助ける活動に関ることが好きだ。
_____ I am keenly aware of my moral beliefs
私は道徳的な信条にとても気づかっている。
_____ I learn best when I have an emotional attachment to the subject
私は科目に情熱的愛着があるとき、一生懸命勉強する。
_____ Fairness is important to me
公平さは私にとって大切である。
_____ Social justice issues interest me
社会正義の問題は面白い。

_____ Working alone can be just as productive as working in a group
一人で作業することは、グループで作業するのと同じくらい生産的です。
_____ I need to know why I should do something before I agree to do it
私は行動をすることに賛成する前に、何かやらなければならない理由を知る必要がある。
_____ When I believe in something I give more effort towards it
何かを信じる時、それに向かってさらなる努力をする。
_____ I am willing to protest or sign a petition to right a wrong
私は誤りを正すために、進んで抗議または陳情書に著名する。
_____ TOTAL for Section 8

Section 9
_____ I can visualize ideas in my mind
私は心の中の考えをイメージ化することができる。
_____ Rearranging a room and redecorating are fun for me
部屋を再配置することや、再び修飾することは楽しい。
_____ I enjoy creating my own works of art
私は自分の芸術作品を創ることが楽しい。
_____ I remember better using graphic organizers
私はグラフや表を用いたほうが、物事をよく記憶できる。
_____ I enjoy all kinds of entertainment media
私は全ての種類のエンターテイメントメディア (TV、ラジオ、映画など) を楽しいと感じる。
_____ Charts, graphs and tables help me interpret data
チャートやグラフ、表はデータを解釈することに役立つ。
_____ A music video can make me more interested in a song
ミュージックビデオよって、より歌に興味をもつ。
_____ I can recall things as mental pictures
私は物事をイメージとして思い起こすことができる。
_____ I am good at reading maps and blueprints
私は地図や青写真を読みとることが得意だ。
_____ Three dimensional puzzles are fun
3次元パズルは楽しい。
_____ TOTAL for Section 9

Part II
Now carry forward your total from each section and multiply by 10 below:
自分の合計「Total Forward」に書き、それぞれに10をかけて「Score」に書いてください。

Section	Total Forward	Multiply	Score
1		X10	
2		X10	
3		X10	
4		X10	
5		X10	
6		X10	
7		X10	
8		X10	
9		X10	

Part III
Now plot your scores on the bar graph provided
自分のスコアを棒グラフにして書いてください。

Part IV

Now determine your intelligence profile!

知能プロファイルの決定です！

Key:

Section 1 – This reflects your Naturalist strength

自然主義者の強さを反映している。

Section 2 – This suggests your Musical strength

音楽的強さを反映している。

Section 3 – This indicates your Logical strength

論理的の強さを反映している。

Section 4 – This illustrates your Existential strength

実存主義の、経験的なの強さを反映している。

Section 5 – This shows your Interpersonal strength

人間関係の力の強さを反映している。

Section 6 – This tells your Kinesthetic strength

運動感覚の強さを反映している。

Section 7 – This indicates your Verbal strength

言語の強さを反映している。

Section 8 – This reflects your Intrapersonal strength

人間関係の、対人関係の力を表している。

Section 9 – This suggests your Visual strength

心に描いた視覚の力を反映している。

Remember:

- Everyone has all the intelligences!
  すべての人がすべての知能をもっています！
- You can strengthen an intelligence!
  能力は高めることができます！
- This inventory is meant as a snapshot in time – it can change!
  この調査はある場面のあなたを表しています—変化できるのです！
- M.I. is meant to empower, not label people!
  M.I.は人を高めるためであり、人の能力を固定化するものではありません。

2. Multiple intelligences Survey for middle and elementary student

2.a Japannese Version

あなたが得意なこと教えてください！

太い線のところで、右側を折ってください。 そして、各文を読んで自分について、正しく表していると思うところに○を付けてください。 一番下まで○をつけたら、紙を開いて右側の枠のＸ印のところに、○をつけてください。 **Which are the following true about you?**		Naturalist	Musical Intelligence	Logical-Mathematical	Verbal-linguist	Visual - spatial	Social interpersonal	Body-Kinesthetic
わたしは花や植物に水をあげるのが好きです。		X						
わたしはペットや動物を世話するのが好きです。		X						
わたしは部屋をそうじするのが好きです。		X						
わたしは歌うのが好きで上手に歌います。			X					
わたしは自由な時間に音楽をきくのが好きです。			X					
わたしは楽器を弾くことができます。			X					
科学や算数は好きな教科です				X				
I like “yubi asobi” game and always win the game				X				
わたしは算数の問題を簡単に解くことができます。				X				
わたしはコミックをたくさん読んで集めています。					X			
わたしはサイエンスフィクションが好きです					X			
わたしは自分でも物語を書きます					V			
わたしは鉄道の路線図を簡単に読むことができます						X		
わたしはジグソーパズルを解くのが得意です。						X		
わたしは絵や図を見てものを理解することができます。						X		
わたしはグループで活動するのが好きです。							X	
わたしは新しい友達を作るのが好きです。							X	
わたしはよく他の人を手伝います。							X	
わたしは人から運動が得意だねと言われます								X
わたしは演劇や舞台が好きです								X
わたしは実験をするのが好きです								X
Totals								

2.b. English version

How Many Intelligences Are You Dominant?

Direction:
Fold the paper vertically on the dark line so that the seven “multiple intelligences” are hidden. Read the statement carefully. Place a checkmark next a statement that is true about you. Then unfold the paper, circle the X in each raw that you checked. Write the total number in each column at the bottom of your paper.
How much intelligence are you dominant in?

Which are the following true about you?		Naturalist	Musical Intelligence	Logical-Mathematical	Verbal-linguist	Visual - spatial	Social interpersonal	Body-Kinesthetic
I like to flush the flowers or plant in my home		X						
I like caring pet or animals		X						
I like to clean my room		X						
I enjoy singing and I sing fairy well			X					
I like listening music in my free time			X					
I can play music instrument			X					
Math and/or science are my favorite subject in school				X				
I like “yubi asobi” game and always win the game				X				
I can solve math problem easily				X				
I like read comic and collect many comics					X			
I like science fiction novel like “Harry Potter”					X			
I am good in writing stories					V			
I can read train line map easily						X		
I am good at solving jigsaw puzzle						X		
I can understand a concept through pictures						X		
I like to work together in group							X	
I like to make a new friend							X	
I am often helping other people							X	
People tell me I am good at sport or dancing								X
I like drama and acting thing out								X
I like to do experiment								X
Totals								

2.c Multiple Intelligence Quiz Japanese version

以下の質問が自分に当てはまるかどうか最低1－最高5の数字で答えてください。回答時間は 20 分です。
一つ一つの問題に、時間をかけすぎないでください。最初に思ったことが本心です。

ことばをつかうこと		論理・数学について	
自分の事を表す言葉をたくさん持っている。		やるべきことは分担してもらうと一番はかどる	
文を書いたり、話したりするのが好きだ		算数・数学や数字を使うことは楽しい	
クロスワードパズルや言葉遊びが好きだ		やることリストをいつも持っている	
言われたとおりにものを覚えることができる		難問や論理パズルを解くのは楽しい	
ディベートや話し合いに参加するのは楽しい		なぜ？と考えるのが好きだ	
物事を他の人に説明するのは簡単だ		時間割がある方がだんぜんはかどる	
本を集めたり、物語を書くのは楽しい		原因と結果の関係がすぐに理解できる	
本をたくさん読むのが好きだ		いつも一つ一つクリアしていくタイプだ	
視覚的なこと		他の人とのかかわり	
色の組み合わせを上手につくることができる		他の人の感覚や雰囲気をつかむことができる	
ジグソーパズルなどをつくるのは楽しい		他の人といっしょにやるときが一番はかどる	
地図を読むのは簡単だ		個人競技よりチーム競技の方が楽しい	
どの方角を向いているかの感覚はある方だ		友達同士の言い合いを整理することができる	
映画のアクションを観るのは好きだ		一人でやるよりもチームでやる方がいいと思う	
他の人の失敗をついつい眺めてしまう		文化の違いを学ぶのは楽しい	
スポーツやゲームの先を読む方だ		知らないところに出ていくことを楽しめる	
物事を覚える時は頭の中で絵を書く方だ		他の人と自分の考えや感じたことを共有するのは楽しい	
音楽的なこと		自然について	
よく頭の中では音楽が流れている		汚い場所がきらいだ	
音楽を聴くと気分が変わる		木や花などの自然の共通点や違いに気づくことができる	
音楽のリズムに乗るのは簡単だ		環境を守るのは本当に大事だと思う	
音楽の一部を聴くと色んな楽器の音が聴きとれる		自然についてのテレビ番組を見るのは楽しい	
音楽が流れていると、時間の流れがわかる		クリーン作戦には必ず参加する	
音程がずれているかどうかが分かる		植物を育てるのは好きだ	
音楽関係の活動は簡単だ		魚釣りやバードウォッチングなどは好きだ	
曲の一部を覚えるのは簡単だ		将来は動物や植物を扱う仕事につきたい	

体をつかうこと		自分自身について	
座っているとき動いたり、指でトントンしたり、もぞもぞしたりしたくなる。		自分自身のことを良く知っている	
体を動かすスポーツをするのは楽しい		親友は少しだけいる	
物事をどう感じるかというのを確かめるのに興味があって、触ってみたり、感触を確かめたりする。		良く話題になる問題について、強い意見を持っている。	
体の二か所以上を同時に動かすことができる		自分のペースでやる時が一番はかどる	
手を使って作業をするのが得意だ		他の人にあまり影響されたりしない	
座ってみているより、実際に参加する方がいい		自分がどう感じるかや、状況によってどうなるかは分かっているつもりだ	
やってみないと分からない		価値や信念についてよく疑問をもつ	
歩いたり走ったりしているときに問題について考えるのが好きだ		自分のことをやっているときが楽しい	

2.d English version

THE MULTIPLE INTELLIGENCE QUIZ

Estimated time required: 20 minutes

For each of the statements below, choose a number between 1 and 5 to rate how the statement describes you.

1 – No, the statement is not at all like me
2 – The statement is a little like me
3 – The statement is somewhat like me
4 – The statement is a lot like me
5 – Yes, the statement is definitely me

Verbal/Linguistic

I can use lots of different words to express myself.
I feel comfortable working with language and words.
I enjoy crosswords and other word games like Scrabble.
I tend to remember things exactly as they are said to me.
I enjoy participating in debates and/or discussions.
I find it easy to explain things to others.
I enjoy keeping a written journal and/or writing stories and articles.
I like to read a lot.

TOTAL

Visual/Spatial

I understand colour combinations and what colours work well together.
I enjoy solving jigsaw, maze and/or other visual puzzles.
I read charts and maps easily.
I have a good sense of direction.
I like to watch the scenes and activities in movies.
I am observant. I often see things that others miss.
I can anticipate the moves and consequences in a game plan (i.e., hockey sense, chess sense).
I can picture scenes in my head when I remember things.

TOTAL

Musical

I often play music in my mind.
My mood changes when I listen to music.
It is easy for me to follow the beat of music.
I can pick out different instruments when I listen to a piece of music.
I keep time when music is playing.
I can hear an off-key note.
I find it easy to engage in musical activities.
I can remember pieces of music easily.

TOTAL

Logical/Mathematical

I work best in an organised work area.
I enjoy maths and using numbers.
I keep a 'things to do' list.
I enjoy playing brainteasers and logic puzzles.
I like to ask 'why' questions.
I work best when I have a day planner or timetable.
I quickly grasp cause and effect relationships.
I always do things one step at a time.

TOTAL

Interpersonal

I can sense the moods and feelings of others.
I work best when interacting with people.
I enjoy team sports rather than individual sports.
I can sort out arguments between friends.
I prefer group activities rather than ones I do alone.
I enjoy learning about different cultures.
I enjoy social events like parties.
I enjoy sharing my ideas and feelings with others.

TOTAL

Naturalistic

Pollution makes me angry.
I notice similarities and differences in trees, flowers and other things in nature.
I feel very strongly about protecting the environment.
I enjoy watching nature programs on television.
I engage in 'clean-up days'.
I like planting and caring for a garden.
I enjoy fishing, bushwalking and bird-watching.
When I leave school, I hope to work with plants and animals.

TOTAL

Body/Kinesthetic	
I like to move, tap or fidget when sitting.	
I enjoy participating in active sports.	
I am curious as to how things feel and I tend to touch objects and examine their texture.	
I am well co-ordinated.	
I like working with my hands.	
I prefer to be physically involved rather than sitting and watching.	
I understand best by doing (i.e. touching, moving and interacting).	
I like to think through problems while I walk or run.	
TOTAL	

Intrapersonal	
I know myself well.	
I have a few close friends.	
I have strong opinions about controversial issues.	
I work best when the activity is self-paced.	
I am not easily influenced by other people.	
I have a good understanding of my feelings and how I will react to situations.	
I often raise questions concerning values and beliefs.	
I enjoy working on my own.	
TOTAL	

3.Multiple Intelligences Characteristic Observation

3a. English Version

Name: **Age:** **Gender:**

MULTIPLE INTELLIGENCES CHARACTERISTIC OBSERVATION

Read all statement bellow. If the statement describes student profile, put mark (O) in the column. If the statement does not describe students' profile, leave it blank.

No	Characteristics	Yes	No
1	Good reasoning skill		
2	Analytical		
3	Uses logic		
4	Uses numbers		
5	Good at problem solving		
6	Sees and recognizes pattern		
7	Enjoys scientific experiment		
8	Able to think about abstract concept		
9	Thinks in 3D		
10	Pictures things in their mind		
11	Great imaginations		
12	Excellent hand to eye relationship		
13	Work with design and color		
14	Good at dancing and sports		
15	Enjoy creating things with their hands		
16	Excellent physical coordination		
17	Tends to remember by doing, rather than hearing or seeing		
18	Participate actively in every activity		
19	Uses body language effectively		
20	Likes to manipulate things with hands		
21	Connects to nature		
22	Classifies or sorts things		
23	Look for and recognize pattern		
24	Outdoorsy		
25	Interested in subjects such as botany, biology and zoology		

26	Good at categorizing and cataloging information easily		
27	May enjoy camping, gardening, hiking and exploring the outdoors		
28	Doesn’t enjoy learning unfamiliar topics that have no connection to nature		
29	Works well with others		
30	Good at sensing others feelings		
31	Empathetic		
32	Uses feedback to improve themselves or a situation		
33	Good at communicating verbally		
34	Good at resolving conflict in groups		
35	See situations from different perspectives		
36	Create positive relationships with others		
37	Enjoy reading and writing		
38	Good at debating or giving persuasive speeches		
39	Good at remembering written and spoken information		
40	Able to explain things well		
41	Good listener		
42	May easily pickup language		
43	Like sound		
44	Enjoy singing, playing an instrument		
45	Recognizes musical patterns and tones easily		
46	Good at remembering songs and melodies		
47	Rich understanding of musical structure, rhythm and notes		
48	Strong sense of self		
49	Keeps a journal or writes down thoughts		
50	Emotionally connected to others		
51	Good at analyzing their strengths and weaknesses		
52	Enjoys analyzing theories and ideas		
53	Clearly understands the basis for their own motivations and feelings		
54	Excellent self-awareness		

c. MI Characteristic Observation Rubric (STEM Camp 2014)

OBSERVER LIST TASK IN TAKING DATA Observer name: ______________

Fill the table below, based on your observation. Count **time** in minutes and seconds, **frequency of question** put how many questions come to you from student in a circle (e.g: ①) or, how many questions did you give to them in triangle (e.g: △)
Put √ for MI characteristic that you see from student
Score 1-4 for creativity and communication skill based on the rubric.
観察に基づいて下の表を埋めてください。**Time** は作業時間を分、秒単位で計測して記入、**frequency of question** は生徒が観察者に質問した回数を○で囲った数字で、観察者が生徒に質問した回数を□で囲った数字で記入してください。**MI characteristic** は観察者から見てできていたら レ を入れてください。**creativity and communication skill** はそれぞれの欄に 1（低）－4（高）の点数を付けてください。

			DATA						
			Time 時間	Frequency (asking questions) 質問の回数	MI Characteristic MI 特性				
ACTIVITY 活動	**GROUP** グループ	**STUDENT NO** 生徒の番号			Good at communicating verbally 言葉で意思疎通できている	Work well with other 他の人とうまく作業できている	Create positive relation with other 他の人と前向きな関係が築けている	Good at remembering spoken information 話された情報をよく覚えている	Good at sensing other feelings 他の人の気持ちをよく考えられている
BINGO CARD									
PUZZLE GAME	GROUP	STUDENT NO	Time 時間	Frequency (asking questions) 質問の回数	Easily find the words 容易に言葉を見つけられる	Good at remembering written information 話された情報をよく覚えている	Excellent hand to eye relationship 手と目の連携が素晴らしい	Able to explain things well 物事を上手に説明できている	Fast in reading and writing 読み書きが速い
CONCEPT MAP コンセプトマップ	GROUP	STUDENT NO	Time 時間	Frequency (asking questions) 質問の回数	Good at reasoning skill 理由づけがよくできている	Uses numbers 数字を使えている	Good at problem solving 問題解決が良くできている	Sees and recognize pattern パターンを認識、理解できている	Work with design and color デザインや色を使って活動できている

LECTURE 講義	GROUP	STUDENT NO	Time 時間	Frequency (asking questions) 質問の回数	Good listener 聞くのがうまい	Enjoy watching pictures 絵を見るのを楽しんでいる	May easily pickup language 容易に言語を受け取れる	See situation from different perspectives 異なった見方で状況をとらえられる	Empathetic 共感できる
BOOTH ブース	GROUP	STUDENT NO	Time 時間	Frequency (asking questions)* 質問の回数	Participate actively in every activity すべての活動に積極的に参加している	Enjoy scientific experiment 科学実験を楽しんでいる	Enjoy creating things with their hand 手を使ってものを作るのを楽しんでいる	Good at resolving conflict in groups グループ内の対立をしっかり解決できる	Connect to nature, search and recognize pattern 自然、探究、パターン認識に結びつけられている
RECONSTRUCT CONCEPT MAP コンセプトマップの再構築	GROUP	STUDENT NO	Time 時間	Frequency (asking questions) 質問の回数	Analytical 分析	Uses logic 理論的使用	Good at classifies or sorts things 分類が上手	Strong senses of self 鋭い感覚	Good at analyzing their strength and weakness 他人の長所、短所の分析が上手

GROUP DISCUSSION グループディスカッション	GROUP	STUDENT NO	Time 時間	Frequency (asking questions) 質問の回数	Emotionally connected to others 他人と情緒的につながっている	Enjoys analyzing theories and ideas 理論やアイディアの分析を楽しんでいる	Thinks in 3D 三次元で考えられる	Great Imagination 想像力に優れている	Good at categorizing and cataloging information easily 簡単に情報を分類するのが得意
SOUND GUESSING	GROUP	STUDENT NO	Time 時間	Frequency (creating instrument) 作った楽器の数	Enjoy playing the instrument 楽器作りを楽しんでいる	Recognize musical tones easily 楽音が容易にわかる	Like sound (creating many sound type) 音が好き（たくさんの音を作っている）	Guess the sound easily 音が容易に言い当てられる	Good at creating new melodies 新しいメロディーを作るのが得意
BIG SOLUTION PROCESS (CONSTRUCT-TEST-RECONSTRUCT) 主な解決過程（構築ーテストー再構築）	GROUP	STUDENT NO	Time 時間	Frequency (creating instrument) 作った道具の数	Creativity Skill (score 1-4)				
					Produce a large number of ideas through an image 想像によりたくさんのアイディアが出せる	Produce a variety of ideas through a design 一つの考えからさらに発展して幾つものアイディアが出せる。	The idea is most unique, from others without neglecting basic principle 基本原理を無視することなく、アイディアが最もユニークである	The product shows superior insight into the theme テーマを洞察するのに優れた製品である	the product can work perfectly with minimum and cheap provided tools 与えられた道具を最小限に安く用い完璧に作動する製品である。

PRESENTATION (SHARE THE RESULT) プレゼンテーション（結果の共有）	GROUP	STUDENT NO	Time 時間	Frequency (creating instrument) 作った道具の数	Communication Skill (score (1-4)				
					Use well-organized language structure with minimal errors 間違いが少なく、良く練られた文章構造である。	Good at giving argumentation 議論の与え方が上手	Speak clearly, briefly to the point 明確に端的に要点を述べている	Answer question logically, stay focus on the theme テーマに焦点を当てながら、論理的に質問に答えている	Understand the question from others by listening carefully 注意深く聞き、質問を理解している。

4. Students' Response to STEM Education Implementation

a) English Version

STEM IMPLEMENTATION QUESTIONAIRE

This survey contains 3 parts: interest, career, and content area in STEM. Read each statement and then circle that best shown your feel.

Part A.

Select one discipline: S = science, T = technology, E= engineering, or M = mathematics in each column.

Question	Most	More	Less	Least
I like:	S T E M	S T E M	S T E M	S T E M
For my career, I like:	S T E M	S T E M	S T E M	S T E M
My family is interested ___in:	S T E M	S T E M	S T E M	S T E M
My family encourages me ___in:	S T E M	S T E M	S T E M	S T E M
I will graduate with college degree	S T E M	S T E M	S T E M	S T E M

Part B

Select one level of argument for each statement to indicate how you feel and think. SD = strongly disagree, D = disagree, U = undecided, A = agree, SA = strongly agree.

Statement	SD	D	U	A	SA
A career in science would enable me to work with other in meaningful ways					
Scientists make a meaningful differences in the world					
Having a career in science would be challenging					
Disaster issues is important					
Solving disaster problem is difficult					
I need more time finishing projects					
I would like to participate more in STEM camp.					

Part C.

Circle one box between the pair adjectives in table below, to show your feeling about STEM content area.

To me, STEM content is

No	Adjectives	A	B	C	D	E	Adjectives
1	魅力的な (appealing)						魅力的でない (unappealing)
2	無意味な (mean nothing)						有意義な (mean a lot)
3	退屈な (boring)						興味深い (interesting)
4	有益な (beneficial)						有害な (harmful)
5	受け身的な (passive)						活動的な (active)
6	理解可能な (understand-able)						不可解な (mysterious)
7	不要 (unnecessary)						必要 (necessary)
8	悪い (bad)						良い(good)
9	見慣れない (strange)						身近な (familiar)
10	弱い (weak)						強い (strong)
11	限りのある (confining)						拡大する (expanding)
12	より多くの (more)						より少ない (less)
13	簡単な (simple)						複雑な (complicated)
14	遅い(slow)						速い (fast)
15	難しい (hard)						易しい (easy)

Adopted from G.Knezek & R. Christensen (2009), Arthurl. L White (2010)

b) Japanese Version

ID number: ______________

Group :____________

b）Japanese version

STEM IMPLEMENTATION QUESTIONAIRE

この調査は、STEM に対する関心、経歴と内容域の 3 点から構成されています。各々の質問を読み、あなた自身に最も当てはまるものに丸を付けて下さい。

Part A.

当てはまる分野を 1 つの選んでください：

S = 科学、T =テクノロジー、E=工学、 M =数学.

質問	最も当てはまる	より当てはまる	あまり当てはまらない	当てはまらない
私は__が好きです。	S T E M	S T E M	S T E M	S T E M
私の将来の仕事として、____が好きです。	S T E M	S T E M	S T E M	S T E M
私の家族は、____に興味を持っています。	S T E M	S T E M	S T E M	S T E M
私の家族は、私に____を勧めます	S T E M	S T E M	S T E M	S T E M
私は、____の学位で大学を卒業したい考えています。	S T E M	S T E M	S T E M	S T E M

Part B

次の文を読んで、あなたの意見に近いものを選んでください。 SD =強く否定する、D =否定する、U =どちらでもない、A =同意する、SA=強く同意する。

声明	SD	D	U	A	SA
科学系の職業では他の人と一緒に意義ある仕事ができると思う。					
科学者はより価値ある世界を構築することができる。					
科学系の職業を持つことは未来に向けて挑戦することだ。					
防災や減災問題は重要だと思います。					
防災や減災問題を解決することは難しいです。					
STEM キャンプでの課題を終えるのにもっと時間がほしいです。					
これからもっと STEM キャンプに参加したいです。					

Part C.

STEM 内容域についてのあなたの印象を A から E の間で一つ選んでください。

私にとって、STEM 内容は：

No	Adjectives	A	B	C	D	E	Adjectives
1	魅力的な (appealing)						魅力的ではない (unappealing)
2	無意味な(mean nothing)						有意義な (mean a lot)
3	退屈な (boring)						興味深い (interesting)
4	有益な (beneficial)						有益でない (harmful)
5	受け身的な (passive)						活動的な (active)
6	理解可能な (understandable)						不可解な (mysterious)
7	不要 (unnecessary)						必要 (necessary)
8	悪い (bad)						良い(good)
9	見慣れない (strange)						身近な (familiar)
10	弱い (weak)						強い (strong)
11	限りのある (confining)						拡大する (expanding)
12	より多くの (more)						より少ない (less)
13	簡単な (simple)						複雑な (complicated)
14	遅い(slow)						速い (fast)
15	難しい (hard)						易しい(easy)

ID number: ______________

Group　　:______________

c. Interview Form to Student

FORMAT WAWANCARA TERHADAP SISWA MENGENAI

IMPLEMENTASI STEM EDUCATION DALAM KELAS

1. Bagaimana respon siswa terhadap pelajaran hari ini;
   a. Menyenangkan
   b. Membosankan
   c. Biasa – biasa saja
2. Bagaimana kegiatan siswa hari ini:
   a. Membuat mereka aktif bergerak
   b. Membuat mereka aktif berpikir
   c. Mereka tidak melakukan apa-apa
3. Apa yang sudah mereka pelajari hari ini:
   a. Tidak mengerti pelajaran yang disampaikan oleh guru
   b. Mengerti sebagian dari pelajaran yang disampaikan oleh guru
   c. Mengerti semua pelajaran yang telah disampaikan oleh guru

TABEL HASIL WAWANCARA

SISWA	PERTANYAAN	JAWABAN		
		a	b	c
	1			
	2			
	3			

Bandung, ______________________

Observer

5. Creativity Tests

a) English Version

Name: Gender: Class:

CREATIVE THINKING TEST

Direction: Do not begin until you are told to do so.

- Try to think of things that no one else will think of
- Try to think as many ideas as possible
- Add details to your ideas to make them complete
- If you finish before time is up, you may continue to add detail, or sit quietly
- Please do not go to next activities before you do so

Activity 1. Answer this question after you told to do so

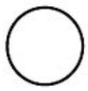
Just suppose that people could transport themselves from place to place with just a wink of the eye or a twitch of the nose. What might be some things that would happen as a result? You have 3 minutes

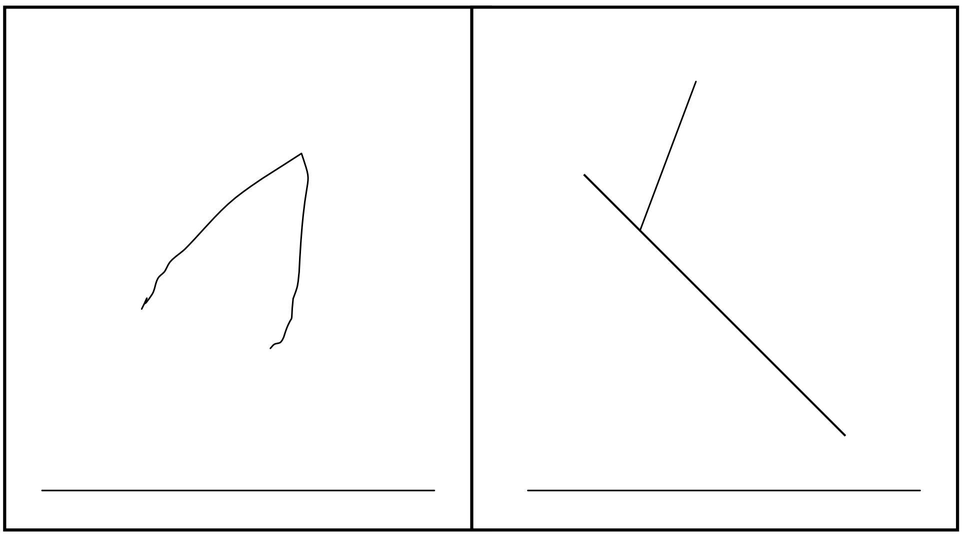
Just suppose we lived in a world without insect. What might be some things that would happen as a result? You have 3 minutes

Pretend that there was no more pollution, what might be the causes of this happen? You have 3 minutes

Activity 2. Add line to incomplete figures bellow to make pictures out of them. Try to tell complete stories with your pictures. Give your pictures titles

You have 3 minutes for each box!

	Starting Shapes	Complete Shape
Use		
Combine		
Complete		



b) Japanese Version

番号

これまでになかったものを

学校名　　　　　　　学年　　　　　　性別　　　名前

指示があるまではじめないでください。
・誰も考えないようなことを考えてみてください
・できるだけたくさんアイデアを出してください
・アイデアには具体的なところまで書いてください
・時間までに終わってしまった人は、具体的なところをもっと書くか、静かに待っていてください。

1. 指示があったら、次の質問に答えてください。
○ある場所から別の場所にあっという間に移動できるとしたら、どんなことが起こりそうですか？3 分

・
・
・
・
・
・

○世界から虫がいなくなったら、どんなことが起こりそうですか？3 分

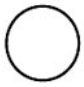
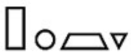
・
・
・
・
・
・

○もし公害が全くなくなったとしたら、その原因は何だと思いますか？3 分

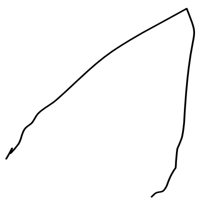
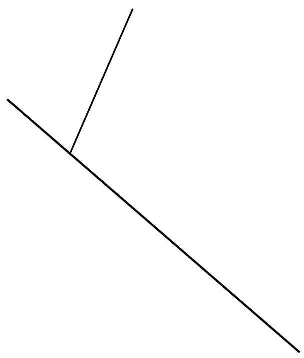
・
・
・
・
・
・

番号＿＿＿＿＿＿

2．以下の絵に線を加えて、あなたの好きな絵を描いてください

はじめの絵	完成図
 この丸を使って	
 この 4 つを組み合わせて	
 この図から初めて	

この図から絵をつくってください。また、図にタイトルをつけましょう

 ＿＿＿＿＿＿＿＿	 ＿＿＿＿＿＿＿＿

6. Teachers' Response

6.1. Self- reflective Assessment

Nama	:
Latar belakang pendidikan	:
Tanggal	:

JURNAL HARIAN

1. Apa yang telah anda pelajari?

2. Masalah apa yang anda hadapi dalam mempelajari hal tersebut?

3. Bagaimana cara anda mengatasi masalah tersebut?

6.2. Likert

STEM EDCATION IMPLEMENTATION QUESTIONAIRE

Berikanlah sikap anda terhadap pernyataan- pernyatan di bawah ini. SS = sangat setuju, S = setuju, TS = tidak setuju, STS = sangat tidak setuju.

PERNYATAAN	SS	S	TS	STS
Saya tertarik untuk menimplementasikan STEM education dalam kelas				
STEM education dapat mengembangkan kreatifitas siswa				
STEM education merupakan landasan ilmu yang sangat penting bagi siswa untuk menghadapi tantangan abad 21				
STEM education mustahil diterapkan dalam kelas				
STEM education dapat diimplementasikan disemua tingkat pendidikan				
Pengintegrasian STEM sulit dilakukan di dalam kelas				
Pengintegrasian sains dan teknologi mudah dilakukan di dalam kelas				
Pengintegrasian sains dan matematika lebih mudah dibandingkan pengintegrasian Sains dan teknologi				
Menghubungkan sains dan matematika sangat sulit bagi saya				
Mengaitkan konsep sains dan engineering merupakan hal yang mustahil				
Mengaitkan konsep sains dan teknologi merupakan hal yang sulit dilakukan				
Untuk mengimplementasikan STEM diperlukan pengetahuan mendalam mengenai sains dan matematika				
Kerjasama antar kolega bidang sains dan matematika akan mempermudah implementasi STEM education				
Program pendalaman konsep sains dan matematika sangat saya butuhkan				
Program pelatihan STEM education bermanfaat untuk meningkatkan profesionalisme saya				
Pelatihan STEM education sebaiknya dilakukan secara berkala				

6.3. Semantic STEM Survey (SSS)

a) Bahasa Indonesia Version

Nama :____________________ (Laki-laki)/(Perempuan) (guru kelas):__________________________

STEM SEMANTIC SURVEY

Quesioner ini dirancang untung menilai percepsi anda mengenai disiplin ilmu IPA dan integrasinya. Pada umumnya waktu yang diperlukan dalam mengisi questioner ini adalah 5 menit. Gunakan kesan pertama anda dalam menjawab questioner ini tanpa berpikir terlalu dalam terhadap setiap pernyataan kata. Quesioner ini dibagi menjadi dua bagian; pretest dan postent. Untuk **pretes**, kondisikan anda dalam situasi **sebelum anda menerima pelatihan pendidikan STEM**, sedangkan untuk **postes**, kondisikan diri anda dalam keadaan ketika anda **telah menerima pelatihan** pendidikan STEM.

PETUNJUK : Lingkari salah satu kotak yang menyatakan sikap anda

PRETES

Buat saya, Sains itu (to me, SCIENCE is)

		a	b	c	d	e	
1	Memikat (fascinating)						Biasa (mundane)
2	mempesona (appealing)						Tidak mempesona (unappealing)
3	menyenangkan (exciting)						Tidak menyenangkan (unexciting)
4	Tidak berarti (mean nothing)						Berarti (mean a lot)
5	membosankan (boring)						menarik (interesting)

Buat saya, matematika itu (to me, MATHEMATICS is)

1	membosankan (boring)						menarik (interesting)
2	Mempesona (appealing)						Tidak mempesona (unappealing)
3	memikat (fascinating)						biasa (mundane)
4	Menyenangkan (exciting)						Tidak menyenangkan (unexciting)
5	Tidak berarti (mean nothing)						berarti (mean a lot)

Buat saya, engineering (teknik) itu (to me, ENGINEERING is)

1	mempesona (appealing)						Tidak mempesona (unappealing)
2	memikat (fascinating)						biasa (mundane)
3	Tidak berarti (mean nothing)						berarti (mean a lot)
4	Menyenangkan (exciting)						Tidak menyenangkan (unexciting)
5	membosankan (boring)						menarik (interesting)

Buat saya, teknologi itu (to me, TECHNOLOGY is)

1	mempesona (appealing)						Tidak mempesona (unappealing)
2	Tidak berarti (mean nothing)						berarti (mean a lot)
3	membosankan (boring)						menarik (interesting)
4	menyenangkan (exciting)						Tidak menyenangkan (unexciting)
5	memikat (fascinating)						biasa (mundane)

Buat saya, karir dalam sains, matematik, engineering dan teknologi itu (to me, CAREER in science, mathematics, engineering and technology is)

1	Tidak berarti (mean nothing)						berarti (mean a lot)
2	membosankan (boring)						menarik (interesting)
3	menyenangkan (exciting)						Tidak menyenangkan (unexciting)
4	memikat (fascinating)						biasa (mundane)
5	Mempesona (appealing)						Tidak mempesona (unappealing)

Buat saya, integrasi Sains, matematika, engineering dan teknologi itu (To me, integration of science, mathematics, engineering and technology (is))

1	mempesona (appealing)						Tidak mempesona (unappealing)
2	Tidak berarti (mean nothing)						Sangat berarti (mean a lot)
3	membosankan (boring)						menarik (interesting)
4	Menguntungkan (beneficial)						merugikan (harmful)
5	pasif (passive)						Aktif (active)
6	Dapat dimengerti (understandable)						misterius (mysterious)
7	Tidak penting (unnecessary)						Penting (necessary)
8	buruk (bad)						Baik (good)
9	asing (strange)						umum (familiar)
10	lemah (weak)						kuat (strong)
11	Terbatas (confining)						luas (expanding)
12	banyak (more)						sedikit (less)
13	sederhana (simple)						rumit (complicated)
14	Lambat (slow)						cepat (fast)
15	sukar (hard)						mudah (easy)

b) Japanese Version

名前(name) :____________________ 男(male)/女(female) 学校名 (institution) :_________________________

セマンティック調査 STEM

このアンケートは、STEM 領域に関するアンケート調査です。あまり思考せずに第一印象でお答えください。本データは本研究の目的のみで使用されます。

以下にさまざまな形容詞がありますが、太字で示された単語に対しての第一印象をまるで示しなさい。a　は左側の形容詞にとても近い印象である。B はやや近い印象である。 c はどちらでもない。 d は右側の形容詞にやや近い印象である。e は右側の形容詞にとても近い印象である。

私にとって、科学が/は (to me, SCIENCE is)

		a	b	c	d	e	
1	すばらしい (fascinating)						平凡な (mundane)
2	魅力的がある (appealing)						魅力のない (unappealing)
3	興奮する (exciting)						ありきたりの (unexciting)
4	何も意味しない (mean nothing)						多くを意味する (mean a lot)
5	退屈な (boring)						興味深い (interesting)

私にとって、数学が/は (to me, MATHEMATICS is)

1	退屈な (boring)						興味深い (interesting)
2	魅力的な (appealing)						魅力のない (unappealing)
3	すばらしい (fascinating)						平凡な (mundane)
4	興奮する (exciting)						ありきたりの (unexciting)
5	何も意味しない (mean nothing)						多くを意味する (mean a lot)

私にとって、工学が/は (to me, ENGINEERING is)

1	魅力的な (appealing)						魅力のない (unappealing)
2	すばらしい (fascinating)						平凡な (mundane)
3	何も意味しない (mean nothing)						多くを意味する (mean a lot)
4	興奮する (exciting)						ありきたりの (unexciting)
5	退屈な (boring)						興味深い (interesting)

私にとって、技術が/は (to me, TECHNOLOGY is)

1	魅力的な (appealing)						魅力のない (unappealing)
2	何も意味しない (mean nothing)						多くを意味する (mean a lot)
3	退屈な (boring)						興味深い (interesting)
4	興奮する(exciting)						ありきたりの (unexciting)
5	すばらしい (fascinating)						平凡な (mundane)

私にとって、科学、数学、工学、技術のキャリアは(to me, CAREER in science, mathematics, engineering and technology is)

1	何も意味しない (mean nothing)						多くを意味する (mean a lot)
2	退屈な (boring)						興味深い (interesting)
3	興奮する (exciting)						ありきたりの (unexciting)
4	すばらしい (fascinating)						平凡な (mundane)
5	魅力的な (appealing)						魅力のない (unappealing)

私にとって、科学、数学、工学、技術の統合は(To me, integration of science, mathematics, engineering and technology (is))

1	魅力的な (appealing)						魅力のない (unappealing)
2	何も意味しない (mean nothing)						多くを意味する (mean a lot)
3	退屈な (boring)						興味深い (interesting)
4	有益 な(beneficial)						有害な (harmful)
5	受動的な(passive)						能動的な (active)
6	理解できる (understandable)						神秘的な (mysterious)
7	不要な(unnecessary)						必要な(necessary)
8	悪い (bad)						良い(good)
9	奇妙な (strange)						みじかな(familiar)
10	弱い (weak)						強い (strong)
11	閉じ込める (confining)						拡大する (expanding)
12	より多い (more)						より少ない (less)
13	単純な (simple)						複雑な (complicated)
14	遅い(slow)						速い (fast)
15	難しい (hard)						簡単な (easy)

7. Puzzle game

a) Japanese Version

カ	ヤ	セ	イ	セ	イ	ブ	ツ	マ	レ	シ	ラ	ジ	オ	エ	ダ	カ	フ	テ	ゲ
コ	ン	ブ	ダ	ナ	リ	ヨ	ク	ン	ナ	ン	デ	ン	キ	キ	オ	テ	ノ	ホ	ベ
ウ	ヂ	チ	レ	ザ	ボ	ル	ャ	ゲ	テ	コ	ロ	マ	キ	ジ	ョ	カ	レ	ボ	ュ
ズ	カ	ゲ	ョ	ー	ヅ	リ	フ	ロ	ワ	ノ	ト	ヨ	ョ	ョ	コ	イ	コ	テ	ビ
イ	ク	ス	グ	ウ	ト	リ	ヤ	ー	ズ	ギ	ゲ	ノ	ダ	ウ	ニ	ク	ア	ド	ガ
ガ	ホ	ハ	セ	ノ	ス	テ	ド	ブ	ミ	ヘ	ナ	ゼ	イ	カ	マ	ニ	ン	セ	ミ
ベ	ウ	フ	イ	ビ	ハ	サ	ク	ス	ロ	カ	ザ	ン	ナ	デ	ノ	ン	ト	ガ	バ
ギ	シ	ソ	リ	シ	ヘ	ツ	ヘ	ト	イ	セ	ケ	ノ	ナ	サ	ャ	ゲ	ヂ	ヅ	ト
ガ	ャ	ン	ゴ	テ	ュ	ボ	イ	ペ	ニ	ト	ム	ブ	ミ	セ	ペ	ン	チ	ベ	ロ
ユ	セ	ン	ワ	ソ	ハ	ツ	ホ	ギ	ヂ	ク	フ	リ	ヨ	ゴ	コ	ン	ビ	カ	ャ
ソ	ン	キ	ハ	ジ	ゴ	ク	ガ	フ	マ	チ	ス	ビ	ウ	ダ	ン	ウ	ョ	チ	ボ
ド	ヨ	サ	ン	ゴ	シ	ョ	ウ	ス	ユ	ヒ	オ	ギ	ガ	ギ	フ	ハ	ツ	ヒ	ゲ
ア	ユ	ブ	ジ	シ	ン	ブ	ハ	ト	ペ	ド	マ	ベ	ン	ノ	ム	ボ	ン	ウ	ホ
モ	セ	カ	マ	ヅ	ツ	ワ	ウ	ア	ジ	ザ	モ	ボ	ツ	ナ	ミ	ギ	ギ	ヨ	ダ
ア	レ	ブ	ザ	ビ	ヨ	ギ	ラ	フ	ロ	ブ	ウ	サ	ラ	ヌ	シ	ジ	ヘ	エ	ト
ヤ	ゴ	ビ	グ	ン	ゲ	ゾ	チ	ビ	ネ	ラ	ビ	ラ	ン	バ	ョ	シ	テ	ヤ	ボ
ツ	マ	ブ	モ	バ	バ	ゲ	ギ	ガ	ユ	デ	フ	ゲ	ャ	ク	ク	デ	ワ	ケ	マ
ヂ	ケ	メ	ヨ	ベ	バ	イ	ラ	イ	ビ	ゴ	ビ	ビ	ド	ベ	ブ	ボ	ネ	ク	ウ
ネ	ジ	デ	イ	リ	ュ	ウ	ニ	ノ	タ	テ	モ	ノ	ノ	ミ	ツ	ク	ョ	エ	シ
チ	ヅ	ネ	ツ	ニ	ブ	ン	ケ	デ	ズ	ジ	ョ	ビ	ヨ	ジ	シ	ン	ケ	イ	ヂ

b) English version

U	H	D	O	X	X	A	W	V	F	Q	Y	S	W	P	G	A	Z	B	C
A	A	T	L	G	X	K	I	O	E	M	M	U	G	L	H	Z	N	L	F
L	S	N	X	O	V	D	L	Z	C	Q	Y	I	R	A	X	F	F	A	O
I	E	Z	N	T	W	Z	D	G	L	C	P	A	A	T	W	Z	E	V	P
Q	I	T	V	L	K	T	L	L	G	X	G	B	I	E	H	Y	L	A	M
U	S	T	R	J	V	O	I	H	N	H	T	R	F	T	I	L	E	C	U
E	M	D	B	A	I	S	F	D	F	O	H	A	B	E	V	O	C	O	D
F	O	H	T	N	N	S	E	H	E	L	B	S	N	C	B	N	T	R	F
A	G	C	Q	A	F	S	W	A	Y	S	O	I	P	T	U	O	R	A	L
C	R	J	U	F	J	M	P	G	R	K	Y	O	B	O	I	J	I	L	O
T	A	H	I	N	D	X	H	O	K	T	N	N	D	N	L	H	C	R	W
I	P	X	Z	A	E	I	V	H	R	G	H	E	K	I	D	G	I	E	G
O	H	I	H	H	Z	Q	V	B	S	T	A	Q	T	C	I	U	T	E	J
N	U	S	F	T	S	U	N	A	M	I	A	A	U	G	N	T	Y	F	Q
W	W	P	E	O	P	L	E	L	T	E	P	T	C	A	G	R	K	D	R
Y	C	G	I	A	N	T	W	A	V	E	V	T	I	I	K	E	M	K	V
D	D	Y	M	P	I	J	P	Z	Z	G	D	L	K	O	A	E	E	I	F
V	V	Z	V	O	L	C	A	N	O	E	S	S	A	H	N	S	W	H	U
O	A	N	U	C	L	E	A	R	R	A	D	I	A	T	I	O	N	Y	P
Q	E	M	A	N	G	R	O	V	E	V	D	F	J	N	O	P	O	I	W

APPENDIX C

THE ANALYSIS INSTRUMENT

1.1. CONCEPT MAP RUBRIC SCORE

a) Mind Map of Tsunami

Domain	Criteria	Score
Creativity	Fluency: Produce not simple idea Produce simple idea	2 1
	Flexibility: Produce ideas which not bounded by the rigid concept Produce a rigid idea	2 1
	Originality: Different from other group ideas In common with other group ideas	2 1
	Abstractness: Produce possible/logic ideas Produce not logic/ not possible ideas	2 1
Knowledge	Logic Not logic Relevant: the ideas are relevant with the right Concept (tsunami) Not relevant: the ideas not relevant with the true concept	1 0 1 0
Related to STEM understanding/ discipline:	Science Technology Engineering Mathematics	1 1 1 1
Grouping	Point grouping: a number of single idea emanating from one idea	2
	Open grouping: three or more idea that are linked in a single chain	3
	Closed grouping: idea that form a closed system (a loop)	4
	Group two or three idea without clear proposition	1 for each group

b) Theme: Natural hazard Disaster

Domain	Criteria	Score
Proposition: the relationship between two concept indicated by a connecting line and linking words	Students produce a valid proposition that connect each concept of the 21 words that provided to them. At least they should produce 11-proposition word.	11 x 1
	Students add examples or objects word connected to the solutions that indicate their STEM knowledge.	1 word = 1
Hierarchy: each subordinate concept more specific and less general than the concept drawn above it.	Hierarchy of Natural Hazard Disaster: Plate Tectonic Level 1: earthquake Level 2: tsunami, eruption, liquefaction, landslide, fire Level 3: lava, volcanic gas, volcanic ash, radiation, run-up water / overflow Level 4: concept as solution related to STEM, i.e.: hazard detector, hazard mitigation	1 level = 5 4 x 5 = 20
Cross link: the relationship shown significant and valid	Cross-link is both valid and significant; illustrate a synthesis between sets of related concept or proposition. Illustrate STEM ideas. Cross-link between landslide can be induced by earthquake and also eruption Cross-link between concept fire, can be induced by earthquake and also eruption	10
	Cross-link is valid but does not illustrate a synthesis between sets of related concept or proposition	2
	Cross-link is unique or creative and illustrate STEM ideas	5
Examples: specific event or object that are valid instance of those designated by the concept label	The examples words for natural hazard disaster: Plants, human, wildlife, transportation, building, electricity, nuclear plant, water pipe.	8 x 1
	Example words for concepts as solution refer to hazard detector, hazard mitigation: Seismograph, evacuation buildings, levee -	Each word = 2
Grouping: the way concept can be linked or joined together	Point grouping: a number of single concept emanating from one concept	2
	Open grouping: three or more concept that are linked in a single chain	3
	Closed grouping: concept that form a closed system (a loop)	4
	Group two or three concept without clear proposition	1 for each group

Adapted from Novak, J.D., & Gowin, D.B (1984).

2.1. Creativity Rubric for TTCT (Torrance Tests of Creative Thinking)

Category	4	3	2	1	0
Fluency	Propose a large number of idea	Propose numbers of idea	Propose small number of	Propose one idea through	Can not propose an idea
flexible	Produce a variety idea to use, combine and complete the picture	Produce a variety idea to use, combine and complete the picture	Produce a variety idea to use, combine and complete the picture	Produce a rigid idea to use, combine and complete the picture	Produce classic idea to use, combine and complete the picture
originality	the idea is most unique from other idea without neglecting basic principle	the idea is less expected from other group idea without neglecting basic principle	the idea have less common with the other group	the idea in common to other group	the idea is same as the other group
abstractness	produce clear, and detail idea in every parts	produce clear and detail idea in some parts	produce undetailed but clear idea in some parts	produce detail but unclear idea in some parts	produce unclear and undetailed idea in whole parts

2.2 Creativity rubric of the solution idea for tsunami issues

Category	4	3	2	1	0
Fluency	Propose a large number of idea	Propose numbers of idea	Propose small number of	Propose one idea through	Can not propose an idea
flexible	Produce a variety idea related to tsunami	Produce a variety idea related to tsunami	Produce a variety idea related to tsunami	Related to tsunami	Produce classic idea related to tsunam

originality	the idea is most unique from other idea without neglecting basic principle	the idea is less expected from other group idea without neglecting basic principle	the idea have less common with the other group	the idea in common to other group	the idea is same as the other group
abstractness	produce clear, and detail idea in every parts	produce clear and detail idea in some parts	produce undetailed but clear idea in some parts	produce detail but unclear idea in some parts	produce unclear and undetailed idea in whole parts

2.3. Creativity rubric of the solution design for natural hazard solution adapted from NRC, 2002

Category	4	3	2	1	0
Fluency	Produce a large number of idea through an image related to tsunami, volcano, fire, nuclear plant	Produce numbers of idea through an image related to three disaster type	Produce small number of idea through an image related to two disaster type	Produce one idea through an image related to one disaster type	Can not produce an idea through an image
flexible	Produce many variety kind idea in design the solution related to tsunami, volcano, fire, nuclear plant	Produce a number variety kind idea in design the solution related to three disaster type	Produce a small variety idea in design the solution related to two disaster type	Produce a rigid idea in design the solution related to one disaster type	Produce classic idea in design the solution
originality	the idea is most unique from other idea without neglecting basic principle	The idea is less expected from other group idea without neglecting basic principle	The idea have less common with the other group	The idea in common to other group	The idea is same as the other group

abstractness	Produce clear, and detail design in every parts	Produce clear and detail design in some parts	Produce undetailed but clear design in some parts	Produce detail but unclear design in some parts	Produce unclear and undetailed design in whole parts

2.4. Creativity rubric of the solution design for flood issues

Category	4	3	2	1	0
Fluency	Propose a large number of idea	Propose numbers of idea	Propose small number of	Propose one idea through	Can not propose an idea
flexible	Produce a variety idea in the design the flood detector	Produce a variety idea in design the flood detector	Produce a variety idea in the design of flood detector	Produce a rigid idea in design the flood detector	Produce classic idea in design the flood detector
originality	the idea is most unique from other idea without neglecting basic principle	the idea is less expected from other group idea without neglecting basic principle	the idea have less common with the other group	the idea in common to other group	the idea is same as the other group
abstractness	produce clear, and detail design in every parts	produce clear and detail design in some parts	produce undetailed but clear design in some parts	produce detail but unclear design in some parts	produce unclear and undetailed design in whole parts

APPENDIX D

ANALYSIS OF STEM EDUCATION IMPLEMENTATION CHALLENGES

1. Implementation of Technology and Engineering

Put checklist (√) to indicate the implementation of Technology and Engineering in your STEM Program

Elements	Exemplary	Implementing	Emerging	Non-STEM
Integration of science and math used in lessons	Math and science concept are used in the processes of problem based learning (PBL) in every booth activity and design solution.	The booth and design activities are focus on one primary subject area (math or science) with strong connection to math or science	The booth and design activities are focus on only one primary subject area (math or science) with the connection of math or science.	The booth and design activities are focus in one subject area (math or science) with teacher-centered strategies
Technology used in lessons	Is used to collect, record, analyze, and represent data. It is used in the same manner as STEM professionals	Is used to collect and/or record data, and it is used similar manner as STEM professionals.	It is used as a trial to research facts and/or for presentation	Is used as a tool for presentation
Engineering designs used in lessons	are used to guide the processes of problem based learning (PBL) with full integrity of each step. Students collaborate during the processes toward the best solution	are used to guide the processes of problem based learning (PBL) with a loose interpretation of each step.	are used to guide the processes of problem based learning (PBL)	No applicable (there are no engineering designs)
STEM Area Professionals	Are mentors and partners for students throughout the problem based learning.	Are mentors for the problem based learning (PBL) processes partly	Speak to students about STEM in their work	Are guest speakers who explain about what they are doing
Link to careers in STEM field	Are embedded day to day in every dialogues, experience, and outcomes	Are embedded in dialogues and outcomes among students that will come out during the PBL processes	Are mentioned, but not embedded in the PBL processes	Are not integrated in learning at all. It is usually settled down in "career week"
What students are doing	Students are working together to design a	Students are working together to solve a problem.	Students are solving given problems with parameters	Dialogues include confirming knowledge what teachers said.

	solution to a selective problem. Students are communicating toward solution. Students are applying contents to identify parameters, obstacles, etc.	Students are identifying parameters, obstacles, through discussion		Find answer from books.
Autonomy	Student have much autonomy to express their ideas in solving problem at booth activity and design a solution	Students have autonomy to express their ideas at designing solution with less guidance from mentor	Students have autonomy to express their ideas in problem based learning (PBL) processes at booth activities and design solutions with much guidance from mentor	Students don't have autonomy to express their ideas in solving problems at booth activity and design solution

Adapted from Sanguezza, C, 2012, revising by Kumano. Y, Irma. R, 2014

2. Using contexts of STEM

Most significant challenges center on introducing STEM-related issues such as energy efficiency, climate change, and hazard mitigation and developing the competencies to address the issues students confront as citizens. Addressing these challenge requires an educational approach that are settled down in a real-life situations and global issues at the central position and uses the four disciplines of STEM to understand and address the problem. This has been referred to as *context-based science education* (Fensham 2009) and could easily be represented as a context- based STEM education. To apply context Based STEM education, Bybee (2013) suggest 4Ps (purposes, policies, program, practices) to start improve STEM education. Based on this suggestion, we can develop rubric to improve STEM education.

Give your perspective of STEM Education implementation based on the dimension and criteria below. Put checklist (√) at the category on each criterion to express your agreement.

Dimension	**Time**	**Participants**	**Location**	**Products**	**Problems/issues**	**Agreement**
	How long will it take to reform STEM education in	Who will be involved?	Where will the activities occur?	What actual product will be produced	What problems do you anticipate?	How difficult will it be to reach agreement among participant?

	your district, or school?					
Purpose						
Dimension	**Time**	**Participants**	**Location**	**Products**	**Problems/issues**	**Agreement**
Establishing goals for STEM Activities	It needs one week ☐ Less ☐ Fair ☐ More	Actively engage faculties collogues, relevant community and other assets ☐ Actively engage ☐ Fair ☐ Not-engage	It conduct in the location where easy to be accessed by participants ☐ Easy ☐ Fair ☐ Hard	Goals related to STEM purposes to create STEM literate students. ☐ Related ☐ Fair ☐ Not-related	It takes ● risk to students, (Less Fair More) ● cost to the program conductor, (Less Fair More) ● the participants took much responsibility (Less Fair More) ● give a lot of benefits (Less Fair More)	Good communication among participant so that the agreement did not take a lot of time and get fine quality ☐ Good ☐ Fair ☐ Bad
Establishing priorities for STEM goals in the STEM activities	It need one week ☐ Less ☐ Fair ☐ More	Actively engage faculties collogues, relevant community and other assets ☐ Actively engage ☐ Fair ☐ Not-engage	It conduct in the location where easy to be accessed by participants ☐ Easy ☐ Fair ☐ Hard	Improving student's knowledge, attitudes, and skills to identify questions and problems in life situations, to explain the natural and designed world, and to draw evidence- based conclusions about STEM related-issues; ☐ Imply ☐ Fair ☐ Not imply	It takes ● risk to students, (Less Fair More) ● cost to the program conductor, (Less Fair More) ● the participants took much responsibility (Less Fair More) ● give a lot of benefits (Less Fair More)	Good communication among participant so that the agreement did not take a lot of time and get fine quality ☐ Good ☐ Fair ☐ Bad

Dimension	Time	Participants	Location	Products	Problems/issues	Agreement
Providing justification for STEM education	It need one year ☐ Less ☐ Fair ☐ More	Actively engage faculties collogues, relevant community and other assets ☐ Actively engage ☐ Fair ☐ Not-engage	It conduct in the location where easy to be accessed by participants ☐ Easy ☐ Fair ☐ Hard	Conductor provides routine STEM education implementation evaluation instrument ☐ Routine ☐ Seldom ☐ Not-routine	It takes ● risk to students, (Less Fair More) ● cost to the program conductor, (Less Fair More) ● the participants took much responsibility (Less Fair More) ● give a lot of benefits (Less Fair More)	Good communication among participant so that the agreement did not take a lot of time and get fine quality ☐ Good ☐ Fair ☐ Bad
Program						
Developing material or adopting a program for STEM	It need one month ☐ Less ☐ Fair ☐ More	Actively engage faculties collogues, relevant community and other assets ☐ Actively engage ☐ Fair ☐ Not-engage	It conduct in the location where easy to be accessed by participants ☐ Easy ☐ Fair ☐ Hard	The products are related to civic phenomena solutions that connected to STEM ☐ Related ☐ Fair ☐ Not-related	It takes less: ● risk to students, (Less Fair More) ● cost to the program conductor, (Less Fair More) ● the participants took much responsibility (Less Fair More) ● give a lot of benefits (Less Fair More)	Good team work among participant so that the agreement did not take a lot of time and get fine quality ☐ Good ☐ Fair ☐ Bad
Implementing the STEM program	It need one month ☐ Less ☐ Fair ☐ More	Actively engage faculties collogues, relevant community and other assets ☐ Actively engage ☐ Fair ☐ Not-engage	It is conducted in the location related civic phenomena that propose in the program. ☐ Related ☐ Fair ☐ Not-related		It takes less: ● risk to students, (Less Fair More) ● cost to the program conductor, (Less Fair More) ● the participants took much responsibility (Less Fair More) ● give a lot of benefits (Less Fair More)	Good team work among participant so that the agreement did not take a lot of time and get fine quality ☐ Good ☐ Fair ☐ Bad

Practices						
Dimension	**Time**	**Participants**	**Location**	**Products**	**Problems/issues**	**Agreement**
Changing teaching strategies for STEM	It need 4 month ☐ Less ☐ Fair ☐ More	Actively engage faculties collogues, relevant community and other assets ☐ Actively engage ☐ Fair ☐ Not-engage	It conducts in the location where easy to be accessed by participants ☐ Easy ☐ Fair ☐ Hard	Better teaching strategies and stories in STEM ☐ Worse ☐ Better ☐ Best	It takes ● risk to students, (Less Fair More) ● cost to the program conductor, (Less Fair More) ● the participants took much responsibility (Less Fair More) ● give a lot of benefits (Less Fair More)	Good communication among participant so that the agreement did not take a lot of time and get fine quality ☐ Good ☐ Fair ☐ Bad
Adapting materials to unique needs of teacher, schools, and students	It need 4 month ☐ Less ☐ Fair ☐ More	Actively engage faculties collogues, relevant community and other assets ☐ Actively engage ☐ Fair ☐ Not-engage	It conducts in the location where easy to be accessed by participants ☐ Easy ☐ Fair ☐ Hard	Producing unique materials that needed by teacher, schools and students ☐ Unique ☐ Fair ☐ Simple	It takes ● risk to students, (Less Fair More) ● cost to the program conductor, (Less Fair More) ● the participants took much responsibility (Less Fair More) ● give a lot of benefits (Less Fair More)	Good communication among participant so that the agreement did not take a lot of time and get fine quality ☐ Good ☐ Fair ☐ Bad

Adapted from Bybee (2013)

Shizuoka, ____________________

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APPENDIX E

STUDENTS' RESULT

1. Students' solution ideas at STEM Camp Activity 2013

	Ideas			
	Pretest		Post-test	
				utilize
	1	make mountain absorb water little by litte	1	breeding with the water sound
	2	make a pump which can absorb water in the sea and decrease the water of the sea	2	buiild a DAM
	3	produce something more hot than the sun to evaporate the water	3	refine the water to be a drinking water
	4	hit the train to tsunami	4	produce electric power
	5	made an engine from iron to hit the tsunami	5	be immortal
	6	do pumpkin launcher to the sea	6	attach the place to the other
	7	using big marble and slides like the roler coaster to decrease the tsunami water	7	create many high ground
	8	suck the sea water and hit it on tsunami	8	living on the place
	9	drop asatelite in tsunami	9	move to other place
	10	crush tsunami by something heavy	10	making a shelter
	11	give a bigger shock than earthquake	11	making a cube folded shelter
	12	if we give a bigger shock than earthquake, the tsunami will be bigger. And if we would like to crush tsunami, the tsunami will go to the opposite way	12	build the underground shelter
	13	create a place for the refugee in the house basement	13	replace the water from the ocean
	14	draw the wave and hit the high dike	14	being a Titan
	15	build a tough and high building and place , where people can evacuate from tsunami	15	being bigger man
	16	develop the large scale robot that can save people from tsunami	16	being ready
			17	live in the high island
			18	live in the high place (3x)
			19	live in the island areas
			20	make a high and thick dike
			21	weaken the power
			22	build a dike around the country
			23	defend from tsunami
			24	stop tsunami
			25	stop the earthquake
			26	tripple an embarkment

	17	make robot who can help people who are sinking	27	change the sea from liquid to solid
	18	meke a high building/dike, because if it is high it will not dagerous	28	freeze the tsunami
	19	create a rooler coaster rolling on the surface of water	29	make the place which will never be attacked by tsunami
	20	prepare something to protect us	30	live in the underground (2x)
	21	make a big pumkin louncher to fly	31	live in the marine fishers' house
	22	make a pumpkin launcher	32	make all country fly
			33	stick to the sea
			34	runaway with the high speed shoes
			35	fix many plates, and make more than one
			36	destroy the plate (underground)
			37	run away
			38	go to the space
			39	run away by a helicopter
			40	big jump
		Problem::	1	not live near the sea
	0	we cant go outside	2	live in the prefecture without sea
	1	built dike that can be up and down	3	evacuate to mountain for safety
	2	built an embarkment that can survive from tsunami	4	stay in a mountain
	3	built a dike with a hard frame	5	reach a heaven
	4	built an iron dike	6	make a plant that reach the sky
	5	built 35 m dike	7	live in the sky
		too much money	8	make a bridge that lead us to heaven
	6	fund raising	9	live in underground
	7	ask the country help	10	make another planet
	8	Let the artificial tsunami crash the tsunami	11	live into a tomb
		One day before earthquake:	12	live in underground
	9	research the intuition of animal	13	build higher tower to escape
	10	elephant	14	centralize the home to live in and build evacuate tower around the home
	11	dog	15	build an evacuate tower that is as high as tokyo sky tree
	12	catfish	16	You should search the highest tsunami ever, and build the waterbreaker higher than that
	13	call everbody you know		

	14	Take something you need (food, money) and evacuate to the hill from the sea	17	make a thick dike
			18	make high waterbreaker which is higher than tsunami
	15	make the elevator that connect to the mountain	19	make an elastic waterbreaker
	16	evacuate to higher place	20	make an underground shelter
		the plenty energy of tsunam:i	21	make a waterbreaker in the sea
	17	make the wave in control (to be fine)	22	cover the country by the waterbreaker
	18	develop electric generator	23	make a tunnel in the underground that lead us to the sea
	19	produce electricity using prepeler		
	20	collect the wave	24	make the ground below the sea level
	21	put some feather into water	25	make a defence place under the sea
	22	control the tsunami by feather	26	frozen the sea (2x)
	23	Put a float on your bag or belly:	27	cover the sea with board
	24	put a suit of gum and put in the suit	28	having a ceiling (roof) to prevent tsunami
	25	what can we do if it broken?	29	evaporate water by the fire
	26	if it torn, it will not float	30	make a lot of redrained land
	27	have 4 suit	31	plant the sea
	28	ask the neighbour an buy it	32	collect the sea in one place
	29	What can we do if nearly drwan?	33	obliterate/dismis the sea
	30	make a helmet like a shorkel	34	make thousands of holes in the sea and obliterate the sea
	31	how can me make?		
	32	need fund raising:	35	place a float at the basement
	33	ask to the country	36	build the underground building
	34	sell something we developed	37	be caution of tsunami anytime and take action for tsunami
	35	building againts tsunami and earthquake:		
	36	develop something that can turn the water frozen	38	produce a clothes that help us againts the tsunami
	37	develop shelter and tube for animal	39	having something that make you feell calm down when tsunami come
	38	underground shelter and tube	40	having the sun close to the sea
	39	speedy wheelchair that can walk	41	obliterate the plate
				Turn tsunami into:
	40	develop a metal which is stronger than iron and diamond	42	jelly
	41	make a metal that can absorb the impact	43	meatsuyu
			44	cake
	42	make a house which can walk	45	jelly
			46	jus

	43	make the strongest robot that we can enter in	47	custrad puding
	44	make the sun	48	drinking water
	45	dig a hole which connect to the oposite side of the earth	49	build a stairs in the sky
	46	make the underground shelter for food	50	develop something that can walk to the sky
	47	make a dike	51	develop the equipment that can predict the earthquake 30 times earlier
	48	if you make a adike tsunami will become weak	52	carry something that can float on the water
	49	nedd a lot of money	53	plant dried trees and let it absorb the water
	50	we need fund raising	54	develop a car that can start running immediateky
			55	learn swim
			56	swim
			57	escape to the universe and live there
			58	leave the earth
			59	meke a submarine and escape to the depth of the sea
			60	produce flying car
			61	call doraemon
			62	modify our body to live anywhere
		Tsunami		Evaporate
		Before tsunami:	1	water series:
	1	make a plane or rocket	2	change water into drinking water
	2	dig in the ground	3	collect water
	3	change tsunami water into drinking water	4	turn sea into drink water
	4	safe food in the safety place	5	drink water
	5	each house should have one shelter	6	propeller
	6	make a house which can float		dike group:
	7	have a basement	7	dike
	8	prepare emergency provision	8	hard metal
		Develop:	9	sacrifise someone
		chemist	10	die one time and birth again
	9	make many factories	11	readiness
	10	increase the nature		Fly:

	11	increase the amount of tree	12	become a bird
	12	make a square boat and live in the sea	13	helicopter on the water
	13	create something easy to float	14	get on the bird
	14	air	15	climb the tree
		After tsunami:	16	one cant fly
	15	evaporate water	17	live on bird
	16	heat	18	become superman
	17	escape:hide:		If one cant fly:
	18	live in the mountain	19	become a plate
	19	house	20	stop the time
	20	shelter	21	get the mirracle box
		lack of house:	22	warp
	21	strengthen the building	23	take a chopter (2x)
	22	to defend place	24	time machine
	23	readiness	25	turn to pokemon
		escape: fly	26	dissapear
	24	rocket	27	become big
	25	helicopter	28	doraemon
	26	plane		Defend group:
	27	superman	29	sacrifise the bear
	28	dokodemo-door	30	call gundam
	29	escape:dive into the sea	31	shield
	30	go into a plate	32	san bag: absorb water
	31	drill	33	do something
	32	make submarine:	34	throw something
	33	endure the hugh temperature		money:
	34	which can accommodate many people	35	raise money
	35	big submarine	36	work in bad company
	36	If you have money:	37	fund raising
	37	develop imediately		figure out agood way
		study:	38	dive into underground
	38	mobilize someone	39	underground shelter
	39	read books of submarine	40	stick suctica cup
	40	if you have money:develop it		
	41	make a new alloy	41	Progress science and tecnology to stop tsunami

	42	improve the strength	42	have priority at scientist
	43	gather people	43	make a human plate
		If you don’t have money:	44	collect the plates together
	44	fund raising		Move out:
	45	collect	45	live under the plate
	46	cannot collect	46	live in a boat
	47	work	47	live in a mountain
			48	live in the sky
			49	build a home shape ship
			50	stay on a hill
			51	stay in the space
			52	go to island
				fight:
			53	hide from tsunami
			54	take the electronic capsule
			55	vessel
			56	submarine
			57	be a good safer
			58	store the food in the right place
			59	harden the ground with concrete
			60	leave one's body
			61	renew the hearth
			62	pray to god ask his help
			63	equip the facilities to grow up the talented pe
			64	escape by new car
			65	escape by myself
			66	escape by dokodemo-door
			67	escape to higher place
			68	escape somewhere
			69	escape alone
	1	escape to Tokyo sky tree	1	Can:
	2	escape to mars	1	using boat
	3	flotation ring	2	build many ships
	4	produce very solid concrete	3	live on the ship

	5	produce big and solid dike	4	save money
	6	produce dike using solid iron	5	produce
	7	prepare the helmet stock	6	more production
	8	live in deep sea	7	work
	9	be ready to get oxygen everywhere	8	go to mars
	10	make a big dike	9	live at another planet fly to the moon
	11	make 1 km high dike	10	survey the tsunami
	12	make 50 meters high dike	11	build the big dome
	13	prepare to escape quickly	12	enter the shelter
	14	escape to the mountain/live in the mountain	13	do best with plate:
	15	make stairs for refugee	14	harden the plate with cement
	16	confirm the place for the refuge before tsunami come	15	control the plate
			16	break the plate
	17	ask a 'tengu' to make wind	17	live on a plate
	18	believe christ	18	lost the plate
	19	produce something more solid than concrete	19	brings many plates together and unity them
	20	make a very high building		
	21	escape to the place of refugee (evacuation place)	20	harden magma
	22	escape to the high place	21	fly to the sky
	23	make a big dike	22	big jump
	24	having a big floatation ring to run immediately (2x)	23	escape by plane
			24	live in the cloud
	25	prepare emergency suplier before tsunami	25	keep flying by plane
	26	make a safety room in underground to escape from tsunami	26	move out:
	27	make a big plastic machine which make us float	27	leave your hometown forever
	28	having a very big floatation ring	28	raise the ground
			29	not to live in the low place
			30	live in mountain
			31	go to higher place
			32	people should became a creature that can live in the sea
			33	live in the sea
			34	live under the sea
			35	stick to the sea
			36	dissapear the sea water

			37	having a barier:
			38	make a dike
			39	make 50 and 100 meters dike
			40	save
			41	harden sea
			42	freeze the tsunami water
			43	escape
			44	practice running away
			45	escape by speedy shoes
			46	practice swimming
			47	do not feel the pain
			48	become big
			49	clothes with an oxygen tube and oxygen mask
			50	be ready
			51	civilization development
			52	technology improvement
			53	prepare money
			54	develop
			55	do you know wether the creature form enter the sapce have UFO
			56	UFO
			57	identifying the out space creature
			58	send back tsunami
			59	send back
			60	cause tsunami from ground
		Preparation before happen:		before tsunami:
	1	learn from the past earthquake	1	make a high buildings
	2	lern well from the old book	2	carry the map anytime where the high building to evacuteand how tall tsunami come to the location
	3	learn from the past experience	3	have a pet
	4	escape by the boat	4	build a large scale electric power plant
	5	make sure the road to escape	5	receive tsunami as much as possible and make an electric power plant
	6	measure the counter to escape	6	have an empty room at home
	7	prepare emergency supplies for earthquake	7	extends sands
	8	make a house on the boat		

	9	live far from the sea		8	extend beach. Extend the sea and make the wave slower
	10	live in open sea		9	find the nearest evacuation place
		imagination:		10	make a dike which have 100 degrees, and evaporate the water
	11	jump to another country		11	leave far from the sea
	12	use a high pair of stilts		12	the animal would know the earthquake, give information to human to be ready on the disaster then ready to evacuate
	13	throw the sea water somewhere			
	14	enjoy tsunami			
	15	hold on tight to a utility pole		13	combine the plate with technology
		endure			escape:
	16	pay a visit to a shrine		14	take a helicopter or a plane
	17	pray to the god of the sea		15	take a gundam
	18	make a map of refugee		16	climb the electric pole
	19	communicate with people near your house		17	evacuate to the space by the Gundam
	20	know above level		18	endure: cost a lot
	21	check the place of refugee		19	utilize natural stuff
	22	find out the higher place		20	stairs to the underground
	23	know well around your house		21	what we can do if the water come underground?
	24	decide the place of refugee		22	make a dike without cracks
	25	escape quickly when tsunami come		23	which open when the ship come
		then:		24	outer the tsunami shelter
	26	escape to the high place (5x)		25	make the boarder of house like board
	27	escape to the mountain		26	make very big dike
	28	escape to the mountain/building		27	it cost too much
	29	wrap a house in a capsule		28	make strong and light dike
	30	prepare a capsule which make us float in the garden		29	prevent the fire
	31	prevent panic:		30	an alarm
		then:		31	turn off the gas from the center
	32	mitigation simulation (new science and technology)		32	not appeal
				33	maybe there will be someone who listen nothing because of panic
		then:		34	use polymer which can suck up the water
	34	train well		35	notice the forecast of earthquake
	35	do an earthquake drill frequently		36	tell when the tsunami will happen by observation of plates
	36	make a thick dike		37	counter tsunami with tsunami
	37	make a super dike			

		make building:	38	have a giant who will help us when tsunami come
	38	make many high building	39	mix gums to the plates
	39	make many places for refugee	40	compress the sea
	40	prepare a lodder from a roof of the house	41	freeze the sea
			42	build the house above the high ground
			43	make strong wall around japan by concrete

2. Students' solution design at STEM Camp activity 2014

Group	Student	Illustration of the Design			
		To prepare for the effect of disaster	To predict the disaster	To build home that withstand with disaster	Total solution
A	RS 005	Draw a fire extinguish, two stairs evacuation building, two cup of food	Draw a television and telephone to answer reliable way to predict the disaster	Draw two people who are talking how to prevent from earthquake	Draw home structure that can survive from earthquake
	RS 029	Draw a person who turning off fire using fire extinguish, two people bring injured person using mattress, two people pushing wall then it is pointed to a home picture, and a person who are running to the evacuation building	Draw TV, radio, and hand phone	Draw two home then pointed to other home which is shaking, and draw other home with two circle foot base	Draw a home structure to survive from tsunami, lava landslide, and earthquake
	RS 028	Draw two person watching TV, person who holding fire extinguish, food safety room,	Draw two TV and hand phone with music note symbol	Draw three structure with for long leg, show the design before and after add some soft material into the structure	Draw two stairs home, and draw a triangle foot base for the home that should follow the flow of the rock/plate inside the ground
	RS 025	Draw wall surround the sea and place a home far from the sea	Draw a television and telephone by add a musical note	Draw a rectangle then wrote strong structure	-
	SI0 03	Draw a fire extinguish	Draw a TV with some picture of abstract	-	Two stairs building. Design a

			rectangles and triangles (it might be to show the disaster		diagonal branch to strengthen the structure
	XS 001	Draw high wall near the sea, announcement speaker, and evacuation building	Draw TV, telephone radio	-	-
B	RS 023	Draw two people with a communication tool in their hand. Draw a person who is transmitting the signal to homes	Draw the disaster information process transfer from the predictor instrument to people who share the news on TV	Draw a house with diagonal brace inside	Design a building structure that can survive from earthquake
	X0 02	Draw a communicator radio to announce the disaster	Draw two people, one is running from disaster, the other are watching disaster information from TV	Draw a big wall to protect home from fire	Draw two strong house that can w
	Rs0 27	Draw a water tank, food safety room for disaster, wide room to gather people, two people who bring injure person using mattress	Draw building with signal transmitter on the roof that transmit information to TV, Radio, and HP to answer reliable way to predict natural disaster	Draw a tower with triangle and cubic structure	Draw cylindrical building that withstand to earthquake. and tsunami
	RS 026	Draw a phone, and hummer to break the window of fire extinguish cox	Draw TV and illustrate the information transfer from home to home via TV	Draw a home structure without clear information	Draw home with a strong base

C	HS 005	Draw a place in home to keep torch, food, communication tools (HP and radio)	Draw PC and TV as a reliable way to predict the disaster	Draw diagonal brace structure to build home that can withstand to the disaster	Draw a home that have airplane in the base
	RS 001	Draw a house and a disaster preparation bag to prepare the effect of natural disaster	Draw a television with a mountain picture inside and wrote 'volcanic eruption	Draw three stairs building, thus when disaster come people can go to the third stair	Draw a mountain and a hole in the bottom, a strong wall with holes surround the mountain, two buildings and homes
	HS 002	Draw a bottle and box of food	Draw japan map and the weather symbol such as typhoon, umbrella, clouds	Draw a rectangle building	Draw two rectangle buildings with triangle foot base
	RS 006	Draw a bottle and a box of food but then cross the picture	Draw several small rectangle that arrange seems like japan islands map, and typhoon symbol	Draw a rectangle building	-
	RS 011	Draw a tsunami disaster, a pool of water in front of two wide wall	Draw NO circle	Draw an engineer with cubic structure of building	Draw many walls in mountain surrounding, good arrangement of wind turbines, high wall near the sea, draw a dam near the mountain to transfer water and draw three electricity generator near the dam. Draw a strong building far from mountain

D	X0 04	Draw sea, mountain, evacuation building, people, home, and a speaker announce	Draw TV with the cable and plug and people who deliver news inside the TV.	Draw a house with diagonal brace inside.	draw wind turbine that consist of three fan knifes, a steering wheel and stairs
	RS 012	Draw a TV, person who is watching, a girl who is listening the announcement, two eyes, two ears	A TV, big PC	Diagonal brace structure	Draw a three knifes wind turbine on the top of box with a fan inside
	RS 030	Draw announcement speaker, a person with a box as head cover, person who hide under table, and a person who is eating rice and a big pot of rice	Draw a phone, TV, PC and announcement speaker	Draw a two wall with rubber in between.	Draw a three knifes wind turbine on the top of box with a fan inside
	X0 03	Draw high wall to protect home from tsunami, and draw high evacuation building	Draw TV with two people inside, phone with warning symbol and radio with symbol of sound	Draw diagonal brace structure then point an arrow to a house	Draw a three knifes wind turbine on the top of box with a fan inside, put it into water with one fish
	RS 020	Draw two house and put the fire extinguish outside in the special box	Draw two TV	Draw a person in front of a home, then put two arrow to two other house that mark with circle and cross	Build a house on strong clay.

3. Concept Map Result